Process Initiation Summary Memo
Honolulu High-Capacity Transit Corridor Project

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Prepared for:
City and County of Honolulu

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1.0 Introduction

The purpose of this document is to briefly summarize process initiation tasks, including the development of the Project Purpose and Need, statement of Study Goals and Objectives, of proposed study alternatives and preparation of five draft methodology reports. The methodology reports describe the process to be followed in developing and evaluating information needed to prepare the AA and DEIS. The five methodology reports discuss the evaluation of transportation alternatives, the estimation of capital costs and operating and maintenance costs, the development of travel demand forecasts and financial analysis of the alternatives.

Following the completion of scoping, a sixth methodology report will be prepared documenting the methodologies to be used for assessing environmental, social and economic impacts.

2.0 Project Purpose

The purpose of the Honolulu High-Capacity Transit Corridor Project is to provide improved mobility for persons traveling in the highly congested east-west transportation corridor between Kapolei and the University of Hawaiʻi at Mānoa (UH Mānoa), confined by the Waiʻanae and Koʻolau mountain ranges to the north and the Pacific Ocean to the south. The project would provide faster, more reliable public transportation services in the corridor than those currently operating in mixed-flow traffic. The project would also provide an alternative to private automobile travel and improve linkages between Kapolei, the urban core, UH Mānoa, Waikīkī, and the urban areas in between. Implementation of the project, in conjunction with other improvements included in the Oʻahu Regional Transportation Plan (ORTP), would moderate anticipated traffic congestion in the corridor. The project also supports the goals of the Oʻahu General Plan and the ORTP by serving areas designated for urban growth.

3.0 Project Area Needs

Improved mobility for travelers facing increasingly severe traffic congestion

The existing transportation infrastructure in this corridor is overburdened handling current levels of travel demand. Motorists experience substantial traffic congestion and delay at most times of the day during both the weekdays and weekends. Transit is caught in the same congestion. Travelers on Oʻahu's roadways currently experience 42,000 daily vehicle-hours of delay, which is projected to increase over seven-fold to 326,000 daily vehicle-hours of delay by 2030. Current morning peak-period travel times for motorists from Kapolei to downtown average between 40 and 60 minutes, while recent observations of bus travel times from ʻEwa Beach to downtown ranged from 30 to 80 minutes depending on traffic conditions. By 2030, these travel times are projected to more than double. Within the urban core, most major arterial streets will experience increasing peak period congestion, including Ala Moana Boulevard, Dillingham Boulevard, Kalākaua Avenue, Kapiʻolani Boulevard, King Street and the Nimitz Highway. Expansion of the roadway system between Kapolei and UH Mānoa is constrained by physical barriers and by dense urban neighborhoods that abut many existing roadways. Given the current and increasing levels of congestion, a need exists to offer an alternative way to move within the corridor independent from current and projected highway congestion.

Improved transportation system reliability

As roadways become more congested, they become more susceptible to substantial delays caused by incidents such as traffic accidents or heavy rain. Because of the operating conditions in the study corridor, current travel times are not reliable for either transit or automobile trips. In order to get to their destination on time, travelers have to allow extra time in their schedules to account for the uncertainty of travel time. This is inefficient and results in lost productivity. Because the bus system primarily operates in mixed-traffic, transit users experience the same level of travel time uncertainty as automobile drivers. Recent statistics from TheBus indicate that on a system-wide basis, for all classes of bus routes, 45% of buses were on time, 27% were late and 28% early . In the AM peak period, express were on time 27% of the time, with 38% being late and 35% being early. A need exists to reduce the variability of transit travel times, and provide a system with increased predictability and reliability.

Accessibility to new development in ʻEwa/Kapolei as a way of supporting policy to develop the area as a second urban center

Consistent with the General Plan for the City and County of Honolulu, the highest population growth rates for the island are projected in the ʻEwa Development Plan area (comprised of the ʻEwa, Kapolei and Makakilo communities) which is expected to grow by 170% between years 2000 and 2030. This growth represents nearly 50% of the total growth projected for the entire island. Within this area, Kapolei, which is developing as a "second city" to downtown Honolulu, is projected to grow by 426%, the ʻEwa neighborhood by 123% and Makakilo by 94% between years 2000 and 2030. Accessibility to the overall ʻEwa Development Plan area is currently severely impaired by the congested roadway network, which will only get worse in the future. This area is less likely to develop as planned unless it is accessible to downtown and other parts of Oʻahu; therefore, the ʻEwa/Kapolei/Makakilo area needs improved accessibility to support its future growth as planned.

Improved transportation equity for all travelers

Many lower-income and minority workers live in the corridor outside of the urban core and commute to work in the Primary Urban Center. Many lower-income workers also rely on transit because they are not able to afford the cost of vehicle ownership and operation. In addition, daily parking costs in downtown Honolulu are among the highest in the United States, further limiting this population's access to the downtown. Improvements to transit capacity and reliability will serve all transportation system users, including low-income and under-represented populations.

4.0 Project Goals and Objectives

Goal #1: Improve Corridor Mobility

Discussion: Improved corridor mobility is defined as improved travel times and reliability for corridor person trips, and improved accessibility between residents and desired destinations.

Objectives	Preliminary Measures
Reduce corridor person trip travel times	• Reduction in transit travel times • Reduction in non-transit travel times • Total daily transit travel time savings • Reduction in daily person hours of travel delay
Improve corridor travel time reliability	• Miles and percent of alternative's alignment in exclusive right-of-way
Provide convenient, attractive and effective transit service within the corridor	• Increase in transit mode share • Total daily transit trips • Total daily new riders • Reduction in total daily vehicle trips
Provide transit corridor travel times competitive with auto travel times	• Comparison of transit with auto travel times
Provide capability to increase corridor peak-period person-throughput to serve future demand increases	• Peak-period carrying capacity of transit alternative and resulting roadway network
Connect major trip attractors/ generators within the corridor	• Number of major activity/employment/ residential/special event centers connected by the alternative
Maximize the number of persons within convenient access range of transit	• Level of population and employment within 1/4 mile range of corridor service
Provide safe and convenient access to corridor transit stations	• Level of access to transit stations via the modes most appropriate for the given station location (e.g., in denser urbanized areas such as downtown, primary access focus would be on the pedestrian mode, whereas in less dense outlying areas primary access modes would include feeder bus, automobile (kiss-and-ride and/or park-and-ride) as well as walking and bicycling). Measured by existence and functionality of the access facilities accommodating the identified access modes.

Goal #2: Encourage Patterns of Smart Growth and Economic Development

Discussion: Patterns of smart growth will be encouraged to ensure compatibility between land use policies and transportation policies which minimize the demand for and amount of travel using automobiles in the corridor. Economic development effects will also be considered in terms of both regional and site specific economic development.

Objectives	Preliminary Measures
Provide transit service to designated corridor transit nodes	• Number of designated corridor transit nodes served by the alternative
Encourage transit oriented development in existing and new growth areas	• Potential for transit oriented development in locations served by the alternative as measured by the amount of available land for development or redevelopment and zoning compatibility.
Utilize corridor land use policies/opportunities related to economic development	• Degree to which the alternative utilizes supportive land use regulations/opportunities along the alignment and near stations.
Support economic development of major regional economic centers	• Number of residents within 30 minutes travel by transit to each of two primary regional economic centers: downtown Honolulu, and Kapolei.
Maximize potential for station area development	• Development potential within 1/4-mile of stations as measured by amount of vacant land and/or land which has not reached its development potential

Goal #3: Find Cost Effective Solutions

Discussion: A cost-effective solution is defined as one that meets the project purpose and need and provides a relatively high level of benefit in comparison to its cost.

Objectives	Preliminary Measures
Provide solutions with benefits commensurate with their costs	• Annualized user benefits per annualized dollar cost (capital, operating, maintenance)
Provide solutions which meet the project purpose and needs while minimizing total costs	• Capital costs • Operation and maintenance costs • Total cost per new rider • Operating cost per passenger mile • Hours of user benefit

Goal #4: Provide Equitable Solutions

Discussion: This goal is aimed at ensuring that costs and benefits are distributed fairly across different population groups, with particular emphasis in serving transit dependent communities.

Objectives	Preliminary Measures
Costs and benefits are distributed fairly across different population groups	• Comparison of project impacts versus benefits by geographic area throughout the corridor and island wide
Avoid disproportionate impacts on low income and minority population groups	• Displacement and/or other impacts to low income and minority communities
Provide effective transit options to transit-dependent communities	• Proximity of transit to transit-dependent communities • Connection of transit-dependent communities to desired destinations

Goal #5: Develop Feasible Solutions

Discussion: In relation to this goal, feasibility relates to both financial and engineering aspects including the level of certainty of the availability of required right-of-way (ROW).

Objectives	Preliminary Measures
The cost of building, operating and maintaining the alternative is within the range of likely available funding	• Degree to which the amount of funding required to build, operate and maintain the alternative system is attainable • Proposed share of total project costs from sources other than New Starts Section 5309 funds • Strength of the proposed capital plan • Ability to operate and maintain the transit system after it is built
The alternative is feasible in terms of constructability and ROW availability	• High rating = standard construction/low degree of risk and known available ROW; Low rating = unique or difficult construction/high degree of risk and ROW availability uncertain or doubtful

Goal #6: Minimize Community and Environmental Impacts

Discussion: This goal relates to a wide range of potential effects of proposed alternatives. In addition to minimizing the community and environmental impacts of any proposed transit solution, benefits of the alternatives to community and environmental resources will also be assessed...

Objectives	Preliminary Measures
Minimize impacts on natural and cultural resources	• Use of land including natural areas and parklands • Displacement of and/or other impact to historic resources
Minimize the displacement of homes and businesses	• Number of residents and businesses displaced
Minimize impacts to property access	• Number of properties with access permanently affected by alternative
Provide a solution which enhances safety in the corridor	• Potential for accidents as measured by historical accident rates by mode on given facility types as represented by each alternative
Minimize disruption to traffic operations	• Change in roadway and/or intersection level-of-service
Minimize conflicts with utilities	• Degree to which utilities need to be relocated
Minimize construction impacts	• Daily vehicle miles traveled (VMT) impacted by construction of the alternative • Impact to access to businesses and residences during construction • Duration of construction impacts
Minimize impacts to community and community amenities	• Community facilities/resources affected • Impacts to non-motorized mode facilities • Change in pollutant emissions • Number of affected noise/vibration receivers • Visual impacts/view corridors affected
Reduce energy consumption	• Change in transportation related regional energy consumption
Minimize impacts to future development	• Degree of disruption to the ability of future development to occur

Goal #7: Achieve consistency with other planning efforts

Discussion: The Honolulu High-Capacity Transit Corridor Project will ensure that the study effort is consistent with past and current planning efforts. Consistency with other planning efforts and adopted plans implies a reasonable level of public acceptance and observance of the planning process.

Objectives	Preliminary Measures
Achieve consistency with adopted community plans	• Degree of consistency with adopted community plans (e.g., Primary Urban Center Development Plan, Central O‘ahu Sustainable Communities Plan, ‘Ewa Development Plan) measured as high, medium or low
Achieve consistency with adopted regional plans	• Degree of consistency with adopted regional plan
Achieve consistency with adopted state plans	• Degree of consistency with Hawai‘i State Plan (Chapter 226, Section 226-17, Hawai‘i Revised Statutes)

5.0 Proposed Study Alternatives

The alternatives proposed for evaluation in the AA were developed through a screening process intended to refine all possible and reasonable alternatives into those that will meet corridor needs, have been identified as technically feasible, and are viable for further study. The range of possible alternatives was developed based on previous transit studies, a field review of the study corridor, an analysis of current housing and employment data for the corridor, a literature review of technology modes, and work completed by the O‘ahu Metropolitan Planning Organization (OMPO) for its Draft 2030 Regional Transportation Plan. Alternatives that emerge from the AA will receive further consideration in the draft EIS.

The screening process identified four alternatives for evaluation in the Alternatives Analysis:

- No Build Alternative
- Transportation System Management Alternative
- Bus in Managed Lanes Alternative
- Fixed-Guideway Alternative

Alternative 1: No Build Alternative

The No Build Alternative includes existing transit and highway facilities and committed transportation projects anticipated to be operational by 2030. Committed transportation projects are those programmed in the O‘ahu 2030 Regional Transportation Plan prepared by

OMPO. The committed highway elements of the No Build Alternative will also be included in the build alternatives (discussed below).

The No Build Alternative's transit component would include an increase in fleet size to accommodate growth in population, while allowing service frequencies to remain the same as today. The specific number of buses, as well as required ancillary facilities, will be determined during the preparation of the AA.

Alternative 2: TSM Alternative

The Transportation System Management (TSM) Alternative would provide an enhanced bus system based on a hub-and-spoke route network, conversion of the present morning peak-hour-only zipper-lane to both a morning and afternoon peak-hour zipper-lane operation, and relatively low-cost capital improvements on selected roadway facilities to give priority to buses. The TSM Alternative will include the same committed highway projects as assumed for the No Build Alternative.

Alternative 3: Managed Lane Alternative

The Managed Lane Alternative would include construction of a two-lane, grade-separated facility between Waipahu and Downtown Honolulu for use by buses, para-transit vehicles, and vanpool vehicles. High Occupancy Vehicles and toll-paying, single-occupant vehicles also would be allowed to use the facility provided that sufficient capacity would be available to maintain free-flow speeds for buses and the above noted para-transit and vanpool vehicles. Variable pricing strategies for single-occupant vehicles would be implemented to ensure free-flow speeds for high-occupancy vehicles.

Intermediate bus access points would be provided in the vicinity of Aloha Stadium and Middle Street. Bus service utilizing the managed lane facility would be restructured and enhanced, providing additional service between Kapolei and other points ʻEwa of the Primary Urban Center, and downtown Honolulu and the University of Hawaiʻi at Mānoa.

Alternative 4: Fixed-Guideway Alternative

The Fixed-Guideway Alternative would include the construction and operation of a fixed-guideway transit system between Kapolei and the University of Hawaiʻi at Mānoa. The system could use any fixed-guideway transit technology approved by FTA and meeting performance requirements, and could be automated or employ drivers.

Station and supporting facility locations are currently being identified and would include a vehicle maintenance facility and park-and-ride lots. Bus service would be reconfigured to bring riders on local buses to nearby fixed-guideway transit stations.
Although this alternative would be designed to be within existing street or highway rights-of-way as much as possible, property acquisition in various locations is expected. Future extensions of the system to Central Oʻahu, Hawaiʻi Kai or within the corridor are possible, but are not being addressed in detail at present.

A broad range of modal technologies were considered for application to the Fixed-Guideway Alternative, including light rail transit, personal rapid transit, automated people mover, monorail, magnetic levitation (maglev), commuter rail, and emerging technologies still in the developmental stage. Several technologies were selected in an earlier screening process and will be considered as possible options for the fixed-guideway technology. Technologies that were not carried forward from the screening process include personal rapid transit, commuter rail, and the emerging technologies. The screening process is documented in the *Honolulu High-Capacity Corridor Project Screening Report* (DTS, 2006a).

The study corridor for the Fixed-Guideway Alternative will be evaluated in five sections to simplify analysis and impact evaluation in the Alternatives Analysis process and report. In general, each alignment under consideration within each of the five sections may be combined with any alignment in the adjacent sections.

Each alignment has distinctive characteristics, environmental impacts, and provides different service options. Therefore, each alignment will be evaluated individually and compared to the other alignments in each section. The sections that will be evaluated and the alignments being evaluated for each section are listed in Table 1.

Table 1. Fixed-Guideway Alternative Analysis Sections and Alignments

Section	**Alignments Being Considered**
I. Kapolei to Fort Weaver Road	Kamokila Boulevard/Farrington Highway
	Kapolei Parkway/North-South Road
	Saratoga Avenue/North-South Road
	Geiger Road/Fort Weaver Road
I. Fort Weaver Road to Aloha Stadium	Farrington Highway/Kamehameha Highway
III. Aloha Stadium to Ke‘ehi Interchange	Salt Lake Boulevard
	Makai of the Airport Viaduct
	Kamehameha Highway/Camp Catlin Road/Salt Lake Boulevard
	Mauka side of the Airport Viaduct
	Aolele Street
IIV. Ke‘ehi Interchange to Iwilei	North King Street
	Dillingham Boulevard
V. Iwilei to UH Mānoa	Hotel Street/Kawaiaha‘o Street/Kapi‘olani Boulevard with or without Waikīkī Spur
	Hotel Street/Waimanu/Kapi‘olani Boulevard with or without Waikīkī Spur
	Nimitz Highway/Queen Street/Kapi‘olani Boulevard with or without Waikīkī Spur
	Nimitz Highway/Halekauwila Street/Kapi‘olani Boulevard with or without Waikīkī Spur
	Waikīkī Spur
	Beretania Street/South King Street

6.0 Methodology Reports

The following five methodology reports are included as appendices:

A. Alternatives Evaluation Methodology Report
B. Capital Cost Estimating Methodology Report
C. Operating and Maintenance Cost Estimating Methodology Report
D. Travel Demand Forecasting Methodology Report
E. Financial Analysis Methodology Report

Alternatives Evaluation Methodology Report
Honolulu High-Capacity Transit Corridor Project

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CHAPTER 1: INTRODUCTION

The City and County of Honolulu (City), in cooperation with the Federal Transit Administration (FTA), is initiating an Alternatives Analysis (AA), leading to preparation of a Draft Environmental Impact Statement (DEIS), to identify and evaluate high capacity transit service improvements along a corridor between Kapolei and the University of Hawai‘i at Mānoa (UH Mānoa). In preparing an Alternatives Analysis for this project, a methodology will be developed to evaluate the various alternatives for transit improvements in the Honolulu High-Capacity Transit Corridor (HHCTC).

The purpose of the Alternatives Evaluation Methodology Report is to insure that a comprehensive list of specific measures are developed and accepted to evaluate proposed transportation improvement alternatives in the HHCTC. This evaluation methodology report is part of a set of six technical methodology reports that will be used to guide the development of the AA. This report provides both a framework for conducting an evaluation of alternatives and identifies many of the specific criteria and measures that will be used in the alternatives evaluation. The framework included in the evaluation methodology uses criteria that complies with the current FTA *Reporting Instructions for the Section 5309 New Starts Criteria and the Major Capital Investment Projects Final Rule*.[1] This report also incorporates changes to the New Starts evaluation criteria identified in the “Dear Colleague” letter from the FTA Administrator that identifies new and revised measures to evaluate New Starts projects commencing with FY 2006 applications[2].

The framework for evaluating alternatives in the corridor involves the following two sets of criteria:

PROJECT JUSTIFICATION CRITERIA

- Mobility Improvements – the extent to which an alternative provides travel time savings, improved travel time reliability, and increased accessibility for travelers in the corridor; including improved access to low income households and employment;

- Environmental Benefits – the extent to which an alternative provides a benefit to air quality or energy consumption;

- Operating Efficiencies – the extent to which an alternative provides transportation at a reasonable operating cost per passenger mile;

- Cost-Effectiveness – the extent to which an alternative provides a level of transportation system user benefits that is commensurate with its incremental costs (and relative to other alternatives);

[1] *Reporting Instructions For The Section 5309 New Starts Criteria*, prepared by the Office of Planning and Environment, Federal Transit Administration, April 2005, Page 2.
[2] Dear Colleague Letter from Jenna Dorn, *Changes to the New Starts Rating Process*. Washington, D.C.: Federal Transit Administration, April 29, 2005.

- Transit Supportive Land Use, Policies and Future Patterns – the extent to which an alternative is consistent with transit supportive land use plans and policies that have been established for the corridor.

- Economic Development – the extent that an alternative promotes new economic activity within the study area, which includes direct and indirect creation of new businesses and job creation resulting from the major capital investment.

An additional project justification criterion relates to the extent to which existing land use in the corridor supports transit usage, as well as plans and policies that have been developed to create changes in land use to enhance the utilization of transit improvements. As this is not a criterion which would distinguish between different alternatives within the corridor, it will not be used in the AA. However, it will be assessed and reported when applying for FTA New Starts funding.

FINANCIAL CRITERIA

- The amount of funding available beyond Section 5309 funds to support the capital construction of a new fixed guideway for an alternative;

- The strength of the capital funding plan; and

- The ability of the City to operate and maintain the guideway after completion of the project.

ADDITIONAL CRITERIA

In addition to these criteria, the evaluation of alternatives in the HHCTC will address the extent to which alternatives meet the supplemental criteria of Effectiveness and Equity. Effectiveness is defined as the extent to which an alternative achieves the goals and objectives defined in the planning process; and Equity is defined as the extent to which each alternative provides fair distribution of costs and benefits across various subgroups in the corridor.

This evaluation framework is designed to support decision making by the City and the FTA, if Federal New Starts funding is sought for implementation of improvements in the HHCTC. The evaluation methodology incorporates elements of FTA's *Reporting Instructions for the Section 5309 New Starts Criteria, Appendix D, FY 2006 NEW STARTS EVALUATION AND RATING PROCESS, prepared in 2004*. The recommended evaluation framework provides both the quantitative and qualitative material needed for decision making in a manner that will successfully build a consensus among all concerned with selection and implementation of a preferred alternative for the corridor.

The AA is intended to address a number of needs and problems in the HHCTC, including those related to land use, economic development, transportation and related conditions. A set of goals and objectives will be developed for the corridor as part of the AA. The goals and objectives will address the following areas:

- Mobility and Access
- Land Use/Community Development
- Economic Development
- Equity
- Environmental Quality

Within each area, specific needs and issues to be addressed by the transit improvements will be developed. Developing the goals and objectives, as well as the evaluation framework and measures early in the AA process help to focus alternatives development and evaluation in producing information that enables decision makers and stakeholders to assess how well an alternative addresses the needs of the corridor.

CHAPTER 2: EVALUATION MEASURES

The purpose of the AA is to determine the need for and the nature of transit service improvements in the HHCTC. Mobility, land use/community development, economic development and environmental quality goals and objectives need to be identified to lead to the development of a set of evaluation measures to help determine the degree to which the various transit improvement alternatives address these needs. These measures will cover the five areas identified previously as part of the AA, as well as three additional areas required for evaluation purposes, and are as follows:

- Mobility/Access Improvements
- Land Use/Community Development
- Economic Development
- Environmental Quality
- Cost-Effectiveness and Operating Efficiency
- Equity
- Financial Feasibility
- Consistency with Other Plans

The evaluation measures for each area will embrace the framework included in both the current FTA *Major Capital Investment Projects Final Rule* and updated guidance prepared to implement changes in New Starts Evaluation criteria that are included in the SAFETEA-LU legislation. Additional measures that cover "other factors" in transit operations will be included in the evaluation process to provide the City with an opportunity to convey other institutional and policy measures that may contribute to the success of the project, and provide more support for an alternative to qualify for FTA New Starts funding.

Specific means of addressing the performance of the various alternatives in regard to how well each does (or does not) perform with respect to the problem areas and goals statements must include a mix of both quantitative measures of effectiveness and cost-effectiveness, and qualitative assessments of financial feasibility and equity considerations. The sources of these measures are:

- City and O'ahu Metropolitan Planning Organization (OMPO) information needs for decision making;
- FTA New Starts Criteria (in anticipation of applying for federal discretionary Section 5309 capital funds); and,
- Issues and needs specific to the HHCTC.

Many of the environmental, economic development, land use and mobility measures are part of the FTA New Starts Project Justification and Financial Criteria for projects seeking discretionary federal capital funds and therefore the information would need to be developed as part of the HHCTC AA and DEIS. An initial set of measures, particularly those that contribute substantially to differentiating among the alternatives, is summarized in Table 1. As the study progresses, and goals and objectives are developed in the study, additional criteria may emerge.

Because of the central role that land use planning has in the AA process, additional measures and methods may be added to this list to further evaluate land use scenarios, economic development effects, and the degree that the transit improvement alternatives support land use policies and plans. Other measures reflecting local concerns and considerations may also be added. Thus, these measures are subject to change and refinement as the study progresses, particularly as the public and stakeholder outreach activities generate issues and information needs. In addition to the application of evaluation measures outlined in Table 1 to the build alternatives, various evaluation analyses will be undertaken as outlined in Sections 2.1 – 2.3 below.

PROJECT JUSTIFICATION CRITERIA

The Project Justification analysis will measure the extent to which an alternative satisfies the goals and objectives that the transportation improvements are intended to address. This category of analysis will also assess how each alternative addresses the New Starts Project Justification Criteria, including many of the measures in Table 1, such as travel time savings and change in vehicle miles traveled.[3] Methodologies will be developed for other appropriate measures as they are identified.

Mobility Improvements

Introduction

The mobility improvements analysis uses measures to estimate how each alternative improves corridor mobility. Measures evaluated under this analysis include travel time savings, number of low income households served by an alternative and the amount of employment near stations.

Methodology and Calculation

The general methodology for the mobility improvements analysis involves three distinct elements: 1) Using the SUMMIT program to calculate an estimate of transportation system user benefit from the travel demand modeling results for each alternative; 2) Calculating the number of low income households within ½-mile of proposed station areas using 2000 census data; and 3) Identifying the amount of employment within ½-mile of all proposed transit stations. The following methodology

[3] Ibid., page 35 – 41.

TABLE 1
HHCTC ALTERNATIVES ANALYSIS
EVALUATION MEASURES: SOURCES AND RATIONALE

EVALUATION CATEGORY & MEASURE	Method	Source	Rationale
CORRIDOR MOBILITY IMPROVEMENTS			
Total Riders – Annual (millions)	(Total daily system riders) x (annualization factor); also need daily line ridership	Travel forecasting model	FTA New Starts Criteria; Differentiator
New Riders – Annual (millions)	(Total system daily build - total system daily future baseline) x (annualization factor)	Travel forecasting model	FTA New Starts Criteria; Differentiator
Annual Travel Time Savings – Hours (Millions)	[Weekday user benefits (Daily user expenditure savings obtained from the New Starts build alternative (in Hours) - New Starts Baseline)] x [annualization factor]	Travel forecasting model, SUMMIT software	FTA New Starts Criteria; Differentiator
Mobility for Transit Dependents	Low income households and employment within ½-mile of stations	U.S. Census data (Households with income below poverty level) and OMPO data (employment projections by Travel Analysis Zone (TAZ))	FTA New Starts Criteria; Differentiator
Change in Transfers	Total system	Travel forecasting model	Differentiator
Change in Vehicle Miles Traveled	(Daily No-Build baseline – alternative) x (annualization factor)	Travel forecasting model	FTA New Starts Criteria; Differentiator

EVALUATION CATEGORY & MEASURE	Method	Source	Rationale
Reliability of Service	Miles and percent of alternative's total alignment in dedicated (non-shared) alignment from street	Measure off concept plans	Differentiator
Activity Centers and Cultural Sites Connected	Define locations and count	Count from maps of corridor	Informational
Special Event Centers Connected	Define sites and count	Count from maps of corridor	Informational
LAND USE/COMMUNITY DEVELOPMENT & ECONOMIC DEVELOPMENT (illustrative; to be developed)			
Development Potential within Walking Distance of Station Area	High/medium/low rating	Based on land use analyses	FTA New Starts Criteria
Employees within Walking Distance of Station Area	Future year employees within ½-mile of station	Travel forecasting model (TAZ) data/Geographic Information System (GIS) analysis	FTA New Starts Criteria
Residents within Walking Distance of Station Area	Future year residents within ½-mile of station	Travel forecasting model TAZ data/GIS analysis	FTA New Starts Criteria
Potential Transit Oriented Development (TOD) Sites	High/medium/low rating	Based on land use analyses	FTA New Starts Criteria
More as appropriate			
COMMUNITY AND ENVIRONMENTAL QUALITY (to be expanded or revised to address corridor-specific issues)			
Change in Pollutant Emissions	Tons per year	Need Vehicle Miles Traveled (VMT) by mode applied to FTA method	FTA New Starts Criteria; Measurable
US Environmental Protection Agency (EPA) Air Quality Designation for Region	EPA's designation	EPA	FTA New Starts Criteria; Informational

EVALUATION CATEGORY & MEASURE	Method	Source	Rationale
Change in Regional Energy Consumption	British Thermal Units (BTUs) per year	Need VMT by mode applied to FTA method	FTA New Starts Criteria; Measurable
Displacements	Number of residences and businesses	Count from concept drawings	Measurable
Noise/Vibration Affected Receivers	Number of receivers with projected noise levels above FTA impact threshold	Results of general assessment	Differentiator
Local Traffic Effects	Level of service	Results of traffic analysis	Differentiator
Cultural or Natural Resources Affected	Number of historic properties, museums, libraries, community centers, parklands, etc. affected	Based on concept plans and 4(f) and Section 106 assessments	Possible Differentiator
Properties with Access Affected	Number of properties whose access is permanently disrupted	Count from concept drawings	Possible Differentiator
Construction related disruptions	Number of properties whose access is temporarily disrupted	Measured off concept plans	Possible Differentiator
COST-EFFECTIVENESS/COST EFFICIENCY IN TRANSIT OPERATIONS			
Capital Costs	Incremental Capital $	Capital Costing Memorandum	Differentiator
Operating & Maintenance (O&M) Costs	Incremental O&M $	O&M Costing Memorandum	Differentiator
Incremental User Benefits (hours)	Hours of user benefit from improved mobility	Annualized weekday user expenditure savings from SUMMIT travel demand evaluation software	FTA New Starts Criteria; Differentiator

EVALUATION CATEGORY & MEASURE	Method	Source	Rationale
Incremental Costs ($) per Transportation System User Benefit (hours)	$/per hour of user benefit Incremental Annualized Cost divided by Incremental user benefits for the New Start Alternative versus the Baseline Alternative	Sum of annualized capital and O&M costs; FTA New Starts Criteria Technical Methods	FTA New Starts Criteria; Differentiator
Operating Cost per Passenger Mile	Incremental operating cost divided by incremental passenger-mile	Operating costs and passenger miles from Travel forecasting model	FTA New Starts Criteria; Differentiator
Proposed share of total project costs from sources other than New Starts Section 5309 funds	Amount of total project costs provided by sources other than Section 5309 funds	Funding Options Analysis	FTA New Starts Criteria Differentiator
Strength of the proposed capital plan	Qualitative assessment of the proposed capital plan	Funding Options Analysis; Financial Plan; Supporting Documentation from the City and OMPO (i.e., OMPO Regional Transportation Plan (RTP), Transit Capital Financing Plans)	FTA New Starts Criteria Differentiator
Ability to operate and maintain the transit system after a new guideway is built	Analysis of 20-year cash flow summary (using measures identified in FTA's Guidance for Transit Financial Plans)	Capital, and Operating and Maintenance Costing Memoranda; Financial Plan	FTA New Starts Criteria; Differentiator

PLANNING CONSISTENCY			
Evaluation Category & Measure	**Method**	**Source**	**Rationale**
Support of Regional Development	Consistent with past and current planning efforts	Based on Hawai'i State Plan and Transportation for O'ahu Plan TOP 2025	FTA New Starts Criteria; Differentiator
Support of Community Development	Consistent with past and current planning efforts	Based on General Plan for the City and County of Honolulu: Primary Urban Center Development Plan, Central O'ahu Sustainable Communities Plan, and 'Ewa Development Plan.	FTA New Starts Criteria; Differentiator
Equity	Number of Low-Income households within ½-mile of stations or boarding points	Based on land use analyses	FTA New Starts Criteria; Measurable

Source: Parsons Brinckerhoff Quade and Douglas, Inc. 2005.

and calculation methods are based on descriptions contained in the FTA document *Reporting Instructions for the Section 5309 New Starts Criteria*, published in April 2005[4].

The methodology for identifying transportation system user benefits involves using the SUMMIT software tool developed by FTA to calculate the required data. The SUMMIT software tool is utilized after the travel demand modeling for the build alternatives and the Baseline Alternative is completed. After completion of modeling, the SUMMIT software tool will be automatically launched. A report file will be generated that will contain the calculations of the change in user expenditures savings (in hours) between the baseline and build alternatives. These calculations will be annualized by a factor that reflects current levels of transit service (not to exceed 300 hours without FTA approval) to provide a total annual travel time savings.

The methodology for the identification of low income households within a ½-mile of a station involves several steps. First, the census tracts (or fraction thereof) within a ½-mile of a proposed station served by a particular alternative are identified. Next, the number of total households and low-income households are identified for each tract. Using a GIS system or visual estimation, the fraction of each tract within a ½-mile of the stations for the New Start system is determined. To calculate the number of households (total and low income), the fraction for each tract is applied to both the total number of households and the number of low income households to provide the amount of households within ½-mile of a proposed transit station.

The methodology for the calculation of jobs within a ½-mile of a station involves steps similar to those used to identify low income households. First, the census tracts (or fraction thereof) within a ½ mile of a proposed station served by a particular alternative are identified. Next, the number of total jobs is identified for each tract. Using a GIS system or visual estimation, the fraction of each tract within a ½-mile of the stations for the New Starts system is determined. This fraction is applied to the total number of jobs to provide the amount of jobs within a ½-mile of a proposed transit station.

Land Use, Community Development and Economic Development

Introduction

FTA uses information on existing land uses, transit supportive land use polices and future land use patterns to consider whether a project meets the criteria for Section 5309 funding. While an evaluation of land use is not required under federal transit law, TEA-21 (and its successor, SAFETEA-LU) legislation allows FTA to use this as a factor for evaluating a New Starts project. SAFETEA-LU also requires FTA to include Economic Development as a criterion for evaluating a New Starts project. For the purposes of comparing corridor alternatives in the AA, the land use criteria will focus on comparing alternatives to see which are most consistent with transit supportive land use plans and policies that have been established for the corridor.

[4] Ibid., pages 35-41.

Methodology

The land use analysis methodology will use criteria and measures consistent with FTA standards[5] and will focus on assessing which corridor alternatives are most consistent with transit-supportive land use plans and policies. This includes assessing how well each alternative serves places with current or planned high density and/or designated corridor transit nodes. It also includes evaluating the degree to which the alternative utilizes transit-supportive land use regulations/opportunities. Likewise, each alternative will be assessed with respect to how well it supports transit oriented development.

Together, these measures, along with the optional "Other Land Use Considerations", comprise the primary evaluation criteria by which land use related impacts and benefits of the corridor alternatives will be evaluated in the AA.

Also, as noted earlier in this report, Economic Development has been elevated as a distinct evaluation criterion for the Project Justification rating under SAFETEA-LU. Once the FTA issues a final rule for implementing these changes, additional criteria will be developed to allow for the study alternatives to be assessed to determine how they meet the need for economic development in the corridor.

Community and Environmental Quality

Introduction

The analysis of Environmental Benefits determines the net impact than an alternative will have on local and regional air quality, and the net impact on energy consumption that an alternative will have on the surrounding region. The environmental benefits are determined using a series of formulas contained in the April 2005 *Reporting Instructions for Section 5309 New Start Criteria* published by the FTA.[6] The formulas provide data on the net change in annual emissions by criteria pollutant and precursor emissions between the New Starts Baseline Alternative and the build alternatives.

Methodology

The methodology for calculating the environmental benefits is straightforward, with vehicle miles traveled (VMT) and private vehicle class data from the travel demand model used to estimate the annual emissions generated under the New Starts Baseline Alternative and the build alternative. Emission Factors are applied to each vehicle class to generate net change in emissions in comparison between the baseline and build alternatives. A similar calculation is conducted for change in British Thermal Units (BTUs) to measure energy consumption and in carbon dioxide (CO_2) production to quantify the impact to greenhouse gases from the project.

[5] Ibid., pages 57-69.
[6] Ibid., pages 42-46.

A variety of other measures assessing impacts to the community will be developed that address specific local issues of concern. These will likely be related to impacts to natural and cultural resources; visual impacts; traffic circulation, parking and access impacts.

Cost-Effectiveness

Introduction

The cost-effectiveness analysis is a mechanism comparing the total costs of a project to its benefits, measured here by the additional annual transit patronage attracted. The method for determining the cost-effectiveness measure is a formula described in the April 2005 *Reporting Instructions for Section 5309 New Start Criteria* published by the FTA.[7] The output of the formula is an alternative's cost per hour of user benefit relative to the New Starts Baseline Alternative. The Baseline Alternative is designed to represent the most effective solution to transportation problems short of new facility construction. The Baseline Alternative provides a foundation against which it is possible to isolate the added costs and benefits of a capital-intensive alternative[8]. In addition to presenting a comparison of total costs to benefits, the cost index is included here because it has been used by the FTA to rate proposed major capital transportation projects around the country, which are being considered for federal funding.

In using this cost-effectiveness to compare projects against each other, only an ordering of alternatives according to their relative merits is needed rather than the calculation of absolute merits. Since the transportation benefits of an alternative (new riders) are usually the largest component of overall benefits, the ranking of projects based on transportation benefits alone is the same ordering that would result if the secondary benefits were also measured, such as air pollution reduction and energy savings. Therefore, the indirect measurement of secondary benefits is adequate for this evaluation. Direct measurement of the secondary benefits would become critical only if the evaluation were designed to judge the absolute merits of each alternative, whether its total benefits exceed its total costs.

Methodology

The general methodology of this cost-effectiveness analysis translates the capital costs of the alternatives into equivalent uniform annual costs. These uniform annual capital costs reflect assumptions about the economic life of the capital components in each alternative (based on federal guidelines) and the cost of capital (i.e., the discount rate). Uniform annual capital costs are

[7] Ibid, pages 48.

[8] Ordinarily, the cost-effectiveness (c/e) measure for the "build" alternatives is computed relative to a Baseline Alternative. The Baseline Alternative is intended to be a low capital cost, operationally-oriented set of improvements to the No-Build Alternative. Usually, the No-Build Alternative is the corridor's future population and employment with today's transportation system and those improvements that have been adopted and approved by a regional transportation planning agency. FTA requires that a Baseline Alternative including additional low-cost transportation improvements must be developed and this Baseline Alternative will be analyzed and included as part of the FTA cost-effectiveness analysis. Only if a case can be made that the No-Build Alternative will include substantial committed transit service improvements over existing conditions can the No-Build Alternative be considered to serve as the Baseline Alternative.

combined with annual Operations & Maintenance (O&M) expenses and then compared to the benefits of the alternatives--measured by the user benefits from increased mobility accrued from an alternative--to arrive at an index of cost-effectiveness for improving mobility.

Placing the capital costs of the alternatives into a common framework involves calculating a stream of annual costs that is equivalent to their initial investment. These annual costs are referred to as an equivalent annual cost (EAC). The method of computing the EAC is straightforward: an annualization formula, which takes into account the discount rate and the useful economic life of major cost components, is applied directly to the initial year capital cost of each major component. For cost components with relatively long useful lives (over 25 years), this formula is approximately equal to the discount rate. In effect, the EAC represents the amount that would have to be invested each year to maintain the capital stock of the alternative at its initial level. The reason for converting the capital costs of each alternative to equivalent annual costs is so that the EAC can be compared with annual operating statistics and annual passengers, allowing a reasonably uniform analysis of cost-effectiveness.

Because all costs used in the analysis are in constant dollars, the effects of inflation are already taken into account; the discount rate used in the analysis is a "real" discount rate that reflects prevailing interest rates net of the effect of inflation.

As noted above, key assumptions required for the derivation of equivalent annual cost include the choice of discount rates and the effective useful lives of all major cost components. Following recommended FTA practice, a real discount rate of 7 percent is suggested. Assumptions about the effective useful lives of major cost components correspond to the economic lives of the major categories of capital cost. The economic life of heavy construction items, for instance, will be assumed to be 50 years, while buses and rail vehicles will be assumed to have useful economic lives of 12 years and 30 years, respectively, before needing replacement.

Calculation of Cost-Effectiveness Index

The Cost-Effectiveness index measures the benefit that a build alternative will provide, using the Baseline Alternative as the measure against which the build alternative is compared. The index is calculated using a combination of capital costs, O&M costs and transportation system user benefits. The Transportation System User Benefit provides a measure of the benefits of a build alternative, and the resulting index is measured as the cost per hour of transportation system user benefit.

For the purposes of the cost-effectiveness index, the EAC for an alternative is combined with the annual O&M costs to generate a Total Annual Cost (TAC) for each alternative. An incremental cost for each build alternative is calculated by subtracting the TAC for the Baseline Alternative from the TAC for a build alternative. Data from the travel demand model generated for the Kapolei/UH Mānoa corridor is analyzed by the FTA SUMMIT software package to automatically perform the calculations necessary to generate the transportation system user benefit for a build alternative. An FTA-provided spreadsheet is used to generate the Cost-Effectiveness Index based on the formula provided below:

$$\text{Cost per Hour of Transportation System User Benefit} = [\text{TAC}_{(\text{Build Alternative})} - \text{TAC}_{(\text{Baseline Alternative})}] / [\text{Hours of Transportation System User Benefit}]$$

Discussion of Index

A Cost-Effectiveness Index will be calculated for each alternative in the corridor. Table 2 presents a format for the results and input data, including the total capital costs, annual operating and maintenance costs, and new transit riders. The use of a cost-effectiveness measure allows analysis of added benefits and added costs of the corridor alternatives as compared to the New Starts Baseline Alternative.

Other measures of cost-effectiveness will be used to evaluate the build alternatives as measured against the Baseline Alternative if required by FTA.

Operating Efficiency

Introduction

The Operating Efficiency analysis provides a measure of the change in systemwide efficiency for each build alternative, using a methodology defined in *Reporting Instructions for Section 5309 New Starts Criteria.*[9]

Operating Efficiency Methodology and Calculation

Operating Efficiency is defined as the change in total systemwide operating costs per passenger mile in the forecast year (20 years into the analysis period) with the systemwide operating costs of the New Starts Build Alternative compared to the costs under the New Starts Baseline Alternative. Operating cost information will be reported for the entire City transit system, as well as by mode (Bus, Rail) if data is available. This systemwide change in operating cost per Passenger Mile is calculated by the following formula:

[9] Ibid., pages 46-47.

TABLE 2
FTA COST-EFFECTIVENESS INDICES AND INPUT VALUES

Alternative	Annual Capital Costs	Total Systemwide O&M Cost	Total Annualized Cost in Forecast Year (2030) [in current year dollars]	Total Annual Ridership in Linked Trips (forecast year)	Incremental Annualized Cost from Baseline (000's)	Incremental Annualized Ridership in Annual Riders from Baseline (000's)	Transportation System User Benefit
New Starts Baseline					NA	NA	Generated from Travel Demand Model by SUMMIT
New Starts Build Alternatives							Generated from Travel Demand Model by SUMMIT

Source: Parsons Brinckerhoff Quade and Douglas, Inc. 2005.

$$\Delta \text{ Operating Cost per Passenger Mile} =$$
$$[O\&M_{\text{Systemwide (Build Alternative)}} / APM]_{\text{Build Alternative}} - [O\&M_{\text{Systemwide (Baseline Alternative)}} / APM]_{\text{Baseline}}$$

Where
$O\&M_{\text{Systemwide}}$ = Systemwide Annual O&M Costs

APM = Systemwide Annual Passenger Miles

Per FTA criteria, any changes in operating cost per passenger which are greater than 5 cents will be explained in the analysis of results.

EQUITY

Although the updated Project Justification Criteria adopted by FTA in April 2005 does not include a separate equity analysis, it is proposed that this section continue to be included as part of the comparison of alternatives with the Baseline Alternative. The equity analysis will examine the extent to which each alternative provides fair distribution of costs and benefits across various subgroups in the corridor. Equity considerations will be generally considered within three classes:

- The extent to which the transit investments improve transit service to various population segments, particularly those that tend to be transit dependent.
- The distribution of the cost of the alternatives across population segments through the funding mechanism used to cover the local contribution to construction and operation.
- The incidence of any significant environmental effects, particularly in neighborhoods immediately adjacent to proposed facilities.

The equity analysis will be supported by the more detailed environmental justice and Title VI analysis documented in the *Affected Environment and Environmental Consequences* chapter of the AA.

The mobility analysis for low-income households identified in Section 2.1.1 will be included as part of the equity analysis, serving as a proxy for a quantitative analysis of the benefits that each alternative will bring to transit-dependent communities in the corridor. This data will be provided in addition to the qualitative equity analysis included in the comparison of alternatives section.

FINANCIAL FEASIBILITY

The Financial Feasibility analysis will address the three primary measures developed by FTA in the Final Rule adopted in April 2001.[10] The first measure determines the amount of the proposed share of total project costs that will be covered outside of Section 5309 funds. The second measure

[10] Ibid., page 72.

addresses the strength of the proposed funding plan for a build alternative. The final measure will examine the extent to which sufficient funding is available, or can be developed, to support the construction, operation, and maintenance of the entire system once an alternative is constructed. In support of the financial analysis of alternatives for the corridor, as well as the cost-effectiveness analysis, estimates of the capital cost of constructing improvements and the incremental operating and maintenance costs for providing a service will be produced. The methodologies for developing these cost estimates and the financial analysis are covered in separate methodology reports.

The task remaining for the evaluation of the alternatives is to use the measures of financial feasibility to examine the likelihood that sufficient existing and, where necessary, additional funding sources would be available to cover the capital and operating costs of each alternative. The selected measures should be a relatively few number of key indicators of financial impacts.

The financial evaluation will relate to the reasonableness of the capital and operational funding needs of the alternatives relative to the corridor needs, any corridor level funding opportunities (such as special taxing districts or joint development), and the system phasing and development needs. The financial evaluation will also identify the 20-year cash flow as outlined in the *Financial Plan* to ensure that the City has sufficient revenue to operate and maintain an expanded transit system with a build alternative after construction. The financial evaluation will also qualitatively review the capital funding plan to determine if it will meet FTA's requirements for a strong financial plan.

OTHER EVALUATION MEASURES

Additional evaluation measures to supplement those listed above will also be developed for the analysis. These criteria are likely to relate to local corridor issues such as physical feasibility (e.g., constructability and right-of-way availability) other community impacts (e.g. to natural or cultural resources, traffic and non-motorized travel), and consistency with other planning efforts.

CHAPTER 3: SCREENING, EVALUATION AND SELECTION

Evaluating alternatives is at the heart of the decision making process. To assist policy-makers and the general public in this process, the alternatives for the HHCTC will be screened and evaluated using a comparison and ranking process. A screening process will be undertaken to assess all feasible candidate alternative modes, alignments and technologies. The result of the screening process will be a more definitive set of alternatives to be analyzed further in a more detailed alternatives evaluation. The analysis will compare each alternative's potential impacts, benefits and costs using criteria developed as part of the evaluation process. An easy-to-understand evaluation matrix arraying the measures will permit a comparison of the alternatives including key differences and trade-offs between them. As the technical analyses are completed, the evaluation matrix will be updated using results of the analyses. While the primary purpose of the evaluation will be to support local decision making, a secondary purpose will be to address FTA's New Starts Criteria. FTA uses the results of their criteria to "rank" projects each year and advises Congress on which New Starts should receive funding.

CRITERIA

A series of criteria for screening and evaluating the various alternatives within the corridor will be developed building upon the criteria outlined in Chapter 2. These criteria will relate to the definition of the need for improving transportation in the corridor, as well as measuring how well the alternatives achieve other objectives established for the corridor. Initial criteria will be developed based on goals and objectives established initially in the Purpose and Need chapter. The initial criteria will be refined by feedback received during the scoping process, information from existing reports, and data and field analysis of new alignment areas. Once the criteria are selected, they will be used throughout the screening and subsequent evaluation process; however, the information for the evaluation at each "level" will become increasingly more detailed as technical studies are completed. Criteria developed as part of this process will be easily translated to the public and decision makers.

SCREENING

An alternatives screening process will provide a comprehensive review of potential technologies, modal options and alignments within the HHCTC. Alternative screening will start with a long list of alternatives based on different technologies and alignments, which will be refined through a series of steps and processes as outlined below.

This screening will consider all feasible alternatives and provide the information necessary to compare and eliminate a potentially large number of alternatives. Using existing information and material developed for the *Draft 2030 O'ahu Regional Transportation Plan*, all of the initial alternatives will be placed in a matrix and ranked against an agreed upon set of evaluation criteria.

The initial long list of alternatives will be subjected to an analysis that focuses on eliminating non-viable alternatives and alternative alignments. A comparison rating scale (e.g., high, moderate, low) of each alternative will be prepared across a subset of key indicators. This information will be presented to City staff for review and comment.

A key aspect to this phase of the analysis is the identification, at the earliest stage possible, of any potential "fatal flaws". Some "fatal flaws" will indeed eliminate an alternative; however, others can be mitigated by measures such as moving the alignment. Flaws such as political or neighborhood opposition can sometimes be mitigated with an effective public education and involvement program. The format recommended for conducting a "fatal flaw" analysis will be a one or two-day workshop including key team members and City staff. In this workshop the alternatives will be evaluated with the information and data available by arraying the alternatives by criteria applicable to this level of analysis. The initial list of alternatives will be screened to eliminate any alternatives that have fatal flaws, preventing their implementation either because they cannot be built (physical limitations), cannot be environmentally cleared, or cannot be funded at the level necessary. Also eliminated during this phase will be alternatives that wholly fail to meet the goals and objectives and purpose and need of the project. Reasons for dropping or modifying alternatives will be discussed.

The results of the screening process will be a refined set of alternatives to be presented to the general public and relevant agencies for review and comment during Public Scoping. The alternatives may be further screened and refined as a result of more detailed information and comments received during Public Scoping. The screening process will be documented in the *Alternatives Screening Memorandum*, and the resulting alternatives will be defined in the *Conceptual Alternatives Memorandum*.

EVALUATION

The refined alternatives resulting from the screening process will be further defined in order to conduct a more detailed evaluation of them. This will include a more detailed layout of the alternatives to better assess potential engineering constraints, capital costs and specific footprint impacts. It will also include identification of operational parameters to enable more detailed modeling of the alternatives for development of patronage estimates as well as operating and maintenance cost estimates. In developing the information to further define the alternatives, some of the alternatives may be refined further. Because a fairly substantial compendium of data will result from this level of refinement, the definition of alternatives will be structured to supplement the initial summary description of each alternative documented in the *Conceptual Alternatives Memorandum* and will serve as the first version of the *Detailed Definition of Alternatives* report. The preliminary report will function as a source or control document for the entire study, to be updated as alternatives are refined.

The alternatives will be evaluated against each other using a set of evaluation criteria which expand upon those presented in Table 1. These criteria will trace back directly to the project purpose and needs, and related goals and objectives. They will be more detailed than the criteria used in the screening process and will require more extensive analyses. The results of the evaluation will be presented in a variety of tables and figures. A summary of the results will be presented as a matrix showing how each of the alternatives compares with the others across all criteria.

An important issue pertaining to the AA alternative forecasts will be the use of GIS maps. The GIS maps can portray to City staff, policy makers and the general public, the benefits of each of the alternatives. Given the large geographical extent of the proposed alternatives, it will be very important to show the areas of the corridor that will be receiving the most benefits from the alternative. Therefore, to facilitate the analysis process during the AA, a GIS-based system for developing mapping and overlays is recommended.

CHAPTER 4: TRADE-OFF ANALYSIS

An analysis of the trade-offs between alternatives will be undertaken which will expand the discussion of the differences between each alternative provided under the evaluation process described above. In this phase, a more detailed qualitative discussion of the trade-offs between alternatives will take place. The trade-off analysis, as described in the MIS Desk Reference is designed to highlight "the advantages and disadvantages of each option and … (point) out the key trade-offs of costs and benefits that must be made in choosing a course of action".[11] The trade-off analysis accomplishes this step by highlighting all of the primary variations between each alternative in a comprehensive fashion, providing both the advantages and disadvantages of each. Examples of trade-offs that may be documented in this analysis include the distinction between Financial Feasibility and Effectiveness. While a particular build alternative may be very effective in achieving the mobility goals defined for the corridor, the Financial Feasibility may determine that there is not enough fiscal capacity to construct the alternative. This alternative analysis takes a very broad view to help decision makers understand the advantages and disadvantages of each option and to point out the key trade-offs of costs and benefits that must be made in choosing the LPA.

[11] National Transit Institute and Parsons Brinckerhoff Quade & Douglas, Inc., *MIS Desk Reference, Final* Review Draft. Prepared for the Federal Transit Administration and Federal Highway Administration, February 1996., page 13-13.

CHAPTER 5: DOCUMENTATION

The evaluation approach and discussion of results will be presented in the Comparison of Alternatives Chapter of the AA.

REFERENCES

FHWA's Code of Federal Regulations, Title 23, Subchapter H, Part 771. Available at http://www.fhwa.dot.gov/hep/23cfr771.htm

FTA's Appendix D: FY 2006 New Starts Evaluation and Rating Process. Available at http://www.fta.dot.gov/documents /Appendix_D.pdf

FTA's Dear Colleague Letters – Changes to the New Starts Rating Process. April 29, 2005. Available at http//www.fta.dot.gov/legal/guidance/dear_colleague/2004/16301_16573_ENG_HTML.htm

FTA's Final Rule for Major Capital Investments. Federal Transit Administration. 2001. Available at http://www.fta.dot.gov/library/policy/ns/20001/11.html

FTA's Reporting Instructions for the Section 5309 New Starts Criteria. April 2005. Available at http://www.fta.dot.gov/16236_ENG_HTML.htm

Capital Cost Estimating Methodology Report
Honolulu High-Capacity Transit Corridor Project

June 30, 2006

Prepared for:
City and County of Honolulu

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TABLE OF CONTENTS

1.0 INTRODUCTION

The City and County of Honolulu (City), in cooperation with the Federal Transit Administration (FTA), is conducting a study of high-capacity transit service along a corridor between Kapolei and the University of Hawaiʻi at Mānoa. In preparing an Alternatives Analysis and Draft Environmental Impact Statement (AA/DEIS) for the Honolulu High-Capacity Transit Corridor (HHCTC) Project, a methodology will be developed to evaluate the various alternatives for transit improvements in the HHCTC Corridor.

In evaluating alternatives being considered by the City, a series of methodology reports have been prepared that describe the analytical framework for evaluating specific issues. This report describes the methods, data sources, and format for calculating and reporting capital costs for each of the study alternatives. This is essential in determining the financial requirements for a project and provides for cost-effective analyses and project financial planning. This methodology bridges the gap between the very early planning level order-of-magnitude estimates (e.g., $150-$200 million per mile) and the final 100 percent Engineers Estimate in which hundreds of individual items will be detailed and priced. It blends a combination of historical data, conceptual engineering products and allowances for design changes and construction contingencies. This cost estimating methodology provides the flexibility of being applied to pre-planning and planning level analyses, as well as conceptual engineering designs. The contingency factor applied to cost estimates will vary inversely to the level of design detail. Therefore, as the level of design goes up, the contingency percentage will go down.

Management of costs on a project is extremely important. Underestimating costs of a project in the early planning stages may occur for the following reasons:

- A project is not sufficiently defined at an early stage; work is unknowingly and invariably left out.
- A project changes as it develops, work is added but budgets are not increased.
- Costs or unit rates tend to increase during the time from planning to design.
- Construction completion is usually delayed and costs escalate over time.

Of primary importance in developing budgets is the proper use of contingency allowances during the various stages of project development. For example, the initial level of contingency in the early planning phase might be in the range of 50-60 percent. As the project enters the conceptual, preliminary and final engineering phases, the contingency will decrease as the level of confidence increases. By the end of construction document preparation, the contingency is usually at 5-10 percent.

With this as background, the remainder of this report describes how the capital cost estimates will be developed and documented, factors that typically influence construction costs, and the development and use of unit prices, contingency factors and cost multipliers. A sample cost estimate is provided at the end of the report.

2.0 CAPITAL COST DEVELOPMENT

This report identifies the capital cost items and processes which will be included in the preparation of conceptual cost estimates for each study alternative and/or individual segments. The capital costs will be developed using guidelines issued by the FTA requiring use of Standard Cost Categories (SCC) for Major Capital Projects.[1] The intent of this methodology is to promote development of construction cost estimates that, in turn, will result in establishment of an adequate budget for the project.

Following this methodology, items from typical cross-sections will be quantified and priced and will have lower contingencies. Cost items which cannot be accurately determined at this time will have a higher contingency allowance. The cost items will then be multiplied by a quantity to provide an estimate of the total cost of that item. For example, a typical cross-section of double track rail would include guideway, trackwork, electrification and signal/communication cost elements or components. Each component will be grouped and costs estimated separately in accordance with the FTA guidelines.

The methodology allows the summary of quantities to be tracked through the various design phases. For the HHCTC project, all construction and capital costs will be expressed in 4th quarter 2005 dollars, and will be developed from the State of Hawai'i Department of Transportation (HDOT) cost data or based on data retrieved from other transit systems throughout the country. When cost data from sources outside of Hawai'i are used, an adjustment may be made using historic state adjustment factors such as those used in the U.S. Army Corps of Engineers Civil Works Construction Cost Index System or RS Means Construction Cost Data publication. Escalated construction costs, based on Engineering News Record (ENR) construction index trends and other sources, will be shown at the bottom of the project cost summary sheet.

3.0 ESTIMATE LIMITATIONS AND PROJECT SPECIFIC RISK ASSESSMENT

During the conceptual estimating phase of a project, a recurring issue is the evaluation and treatment of risk. Uncertainty can result in a "difference" between the estimated cost of a project as defined during the conceptual phase and the actual cost of the project that is ultimately implemented. Four potential sources of uncertainty are generally recognized.

- Changes in Project scope;
- Changes in design standards;

[1] For detailed technical guidance on the FTA capital costing format, visit the FTA website at www.fta.dot.gov/grant_programs/transportation_planning/major_investment/technical_guidance/15885_ENG_HTML.htm

- Incorrect unit cost/quantity assumptions; and
- Unforeseen problems in implementation.

Each of these sources of uncertainty is discussed below.

3.1 CHANGES IN PROJECT SCOPE

During the conceptual engineering/environmental study phase, preliminary decisions on project scope are made, for example, related to vertical and horizontal alignment, degree of grade separation and other significant alignment issues. As a project progresses through the various stages of evaluation, many of the original project scope definitions that formed the basis of the cost estimate may be updated or revised. To address the potential scope risk, a reasonable allowance will be introduced into the estimate.

3.2 CHANGES IN DESIGN STANDARDS

Similar to the broader uncertainties associated with changes to project scope, changes in design standards during later phases of project development also can lead to changes in project cost. Examples of changes in design standards would be replacing high floor vehicles with low floor vehicles, using a more sophisticated signal system, or changing from a barrier-free fare collection system to the use of fare gates. To address this type of risk, a reasonable allowance may be introduced into the estimate that covers potential design standard changes.

3.3 INCORRECT UNIT COST/QUANTITY ASSUMPTIONS

Potential problems can arise in the assumptions used to develop unit cost or unit quantities. Issues that can affect the accuracy of unit cost include the local demand for construction labor and its impact on wage rates, the bid climate during the construction period (i.e., the level of competition among contractors), and fluctuations in basic material prices. Errors in quantity assumptions are often related to changes in design standards as discussed above. To address this type of risk, a contingency should be used in the estimate that allows for a reasonable fluctuation in quantities and unit pricing.

3.4 UNFORESEEN PROBLEMS IN IMPLEMENTATION

Perhaps one of the largest sources of cost estimating uncertainty is the difficulty in anticipating problems that can only be uncovered in later stages of project development. Items that often are the most susceptible are right-of-way acquisition, utility relocations, hazardous materials, and soil conditions. The estimating methods described above represent professionally accepted standards for preparing capital cost estimates to a level of accuracy that is consistent with the level of project definition. Accuracy is traditionally expressed as a +/- percentage range around the point estimate that has been calculated. As noted earlier, the percentage variance factors are greatest in the early stage of project definition and progressively decrease as project definition increases. For example, for major transit capital projects the expected accuracy range of an estimate prepared at project definition (e.g., up to 15 percent of design) is approximately +30/-25 percent, while at final design, the accuracy range should only be approximately +10/-5 percent.

To address the uncertainties inherent in the estimating process at the conceptual engineering/ environmental study phase of project development, design allowances are used. The use of design allowances is discussed later on in Section 6.0 of this report.

4.0 COST SEGMENTS AND CATEGORIES

The use of FTA's Standard Cost Categories (SCC) and capital cost reporting format is intended to make it easier for both FTA and the City to track, evaluate, and control cost changes. As shown in the table below, the SCC consists of ten items divided into two groups and have been established to provide broad boundaries from which the conceptual engineering cost estimates for each alternative can be compared.

TABLE 1: FTA STANDARD COST CATEGORIES

Group 1 – Construction Related Cost Categories

10	Guideway and Track Elements
20	Stations, Stops, Terminals, Intermodal
30	Support Facilities: Yards, Shops, Admin Buildings
40	Site work & Special Conditions
50	Systems
Group 2 – Project Related Items	
60	ROW, Land, Existing Improvements
70	Vehicles
80	Professional Services (soft costs)
90	Unallocated Contingency
100	Finance Charges

Categories 10 thru 50 represent construction-related items, while categories 60 thru 100 represent project-related items. It is intended that major cost items will be summarized in each category. These costs will be calculated from typical sections during planning and conceptual engineering level design. However, each parameter will include several components that make up the aggregated unit cost. For example, a typical rail station will be a lump sum item with a specified cost, but the unit cost will consist of several items. Unit prices will be developed from final engineer's estimates, completed projects, standard estimating manuals and an application of standard estimating practices. The unit costs include contractor or supplier mark-ups for overhead, profit (risks), mobilization, and traffic control. A contingency will also be applied to each of the cost parameters that will vary with the level of detail of the design. Right-of-way, Vehicles, Soft Costs, Unallocated Contingency and Finance changes are to be included under separate cost categories (see FTA Categories 60-100).

4.1 GUIDEWAY & TRACKWORK (SCC 10)

GUIDEWAY

Guideway costs for rail and non-rail fixed guideway alternatives will include all preparatory work (including earthwork, subgrade preparation, etc) up to the bottom of ballast, track slab or running surface within the guideway limits. Other elements outside of the guideway limits such as roadwork, urban design elements, etc. will be estimated and included under other SCC categories.

The majority of guideway is assumed to be aerial and cut and cover structure. The aerial single or dual structure will consist of columns and substructure at approximately 80-foot spans. The substructure may use piling depending on the soils report. The superstructure will either be cast in place or precast depending on alignment/roadway interfacing and anticipated traffic requirements.

The cut and cover dual or single box structure may include pile or other retained cut section to construct the underground box. The box structure may include piling depending on the preliminary soils report.

The subcost category for guideway items will be developed in a composite section representing a route lineal foot (RLF) of guideway type. The subcategories will include the following:

10.01 Guideway: At-grade exclusive right-of-way
10.02 Guideway: At-grade semi-exclusive (allows cross-traffic)
10.03 Guideway: At-grade in mixed traffic
10.04 Guideway: Aerial structure
10.05 Guideway: Built-up fill
10.06 Guideway: Underground cut and cover
10.07 Guideway: Underground tunnel
10.08 Guideway: Retained cut or fill

Guideway construction, especially in-street segments, will require relocation and/or extensions of utilities, including storm drains, sanitary sewers, electrical, telephone, gas, etc. These elements will be identified in FTA Category 40.02. To account for minor utility adjustments such as short laterals, an allowance per linear foot will be included as a percentage of item costs in the composite section cost. Widening of roadways at specific locations will be included in FTA Category 40.07. Each of the different guideway cross-sections are then compiled, quantified and priced for reference to the FTA standard cost categories. The table on the following page represents the items that are representative in various guideway types.

TRACKWORK

Trackwork will include all trackbed or running surface items above the guideway limits. Bus and other non-rail fixed guideway will have no comparable items. Items in the FTA SCC for trackwork are as follows:

TABLE 2: GUIDEWAY COST ITEMS

Guideway Items						
Item	**Unit of Measure**	**Rail**	**AGT**	**Bus**	**Monorail**	**Maglev**
Sawcut Asphalt	LF	x	x	x	x	x
Sawcut Concrete	LF	x	x	x	x	x
Demolition	LS	x	x	x	x	x
Earthwork	CY	x				
Subgrade Preparation	SF or SY	x				
Track Slab (1st pour)	CY	x				
PCC Pavement	SY			x		
Sub ballast	CY	x				
Aggregate base	CY	x				
Track Relocation	TF					
Sub drains	LF	x				
Trackslab		x				
Structure Excavation	CY	x	x	x	x	x
Structure Backfill	CY	x	x	x	x	x
Furnish Piling (P/C)	LF	x	x	x	x	x
Install Piling (Drilled or P/C)	LF/EA	x	x	x	x	x
Shoring	SF	x	x	x	x	x
Tiebacks	LF	x	x	x	x	x
Waterstops	LF	x	x	x	x	x
Reinforcing Steel: Bridge	LBS	x	x	x	x	x
Structure Concrete Bridge	CY	x	x	x	x	x
Structure Concrete Bridge Footing	CY	x	x	x	x	x
Bearing Pads	EA	x	x	x	x	x
Seismic Isolation Bearings	EA	x	x	x	x	x
Furnish Precast Concrete: Girder	LF				x	x
Install Precast Concrete: Girder	EA				x	x
Misc Metal Bridge	LBS	x	x	x	x	x
Maintenance Walkway	LF	x	x	x	x	x
Barrier Rail	LF	x	x	x	x	x
Duct Bank (various types)	LF	x	x		x	x
Bored Tunnel	RLF	x	x	x	x	X
Cut & Cover Tunnel	RLF	x	x	x	x	X

LF = linear foot, CF = cubic foot, SF = square foot, TF = track foot, RLF = route linear foot, EA = each, LBS = pounds, CY = cubic yards, SY= square yards

1.09 Track: Direct Fixation
1.10 Track: Embedded
1.11 Track: Ballasted
1.12 Track: Special (switches, turnouts)
1.13 Track: Vibration and noise dampening

Unit costs for single, double and triple track sections and special trackwork will be developed. If applicable, it is assumed that a majority of the trackwork in the railroad corridor will be direct fixation. At-grade crossings will have precast concrete planking, rubber or other suitable material between and along the rails.

Trackwork in the in-street segments will consist of embedded, direct fixation girder rails on concrete base slabs. Trackwork costs will be estimated on a track foot basis and will include the following items for ballasted track segments, direct fixation track or embedded trackwork for semi-exclusive right-of way.

4.2 STATIONS, SHOPS, TERMINALS AND INTERMODAL (SCC 20)

The station category includes costs elements for rough grading, excavation, ventilation structures and equipment, station power and lighting, public address/customer information system, safety systems such as fire detection and prevention, security surveillance, access control, communication, landscaping, and life safety systems; finishes and equipment. Also to be included will be all architectural and structural elements for the associated facility, and additional work in the immediate vicinity of the station. This will include the platform, shelters, sidewalks, station communications, lighting, signage, and landscaping. In this methodology report, prototypical stations may be developed. Station layouts may include center, side, or split side platform(s) for both at-grade and aerial guideways. Underground and at-grade station costs will be estimated on a unit basis for each type of station and include the following items:

TABLE 3: STATION COST ITEMS

Stations				
-		Underground	At-Grade	Aerial
-		Station	Station	Station
Excavation Support	LS	x		
Surface Demolition & Site Removal for Surface Access	SF			
Structure Excavation	CY	x	x	x
Structure Backfill	CY	x		
Furnish Piling (P/C)	LF	x		
Install Piling (Drilled or P/C)	LF/EA	x		
Shoring	SF			x

Tiebacks	LF	x		x
Haul & Dispose 12 cy dump 20 mil RT	CY	x	x	x
Allowance for Special Demolition	Allow	x		
TRACK GUIDEWAY				
Single At-Grade Guideway for Direct Fixation Track Stations	TF	x	x	x
INTERIOR STRUCTURAL SHELL				
Waterproofing, Geotextile Exterior Walls	SF	x		
Waterproofing, Geotextile Roof Slab	SF	x		
Sheet Waterproofing, Slab on Grade	SF	x		
CIPC, Cut and Cover Invert Slab	CY	x		
CIPC, Cut and Cover Exterior Walls, Formed 2 Sides	CY	x		
CIPC, Cut and Cover Roof Slab	CY	x		
CIPC, Cut and Cover Interior Walls	CY	x		
CIPC, Ventilation Concrete	CY	x		
Reinforcing Steel	LBS	x	x	x
EXTERIOR ACCESS: STRUCTURAL				
CIPC, Station Vertical Access (Structural Stairs)	VF	x		x
EXTERIOR ARCHITECTURAL				
Vent Grillage	SF	x		
Architectural Treatment (Form Board)	SF	x		
ARCHITECTURAL				
Architectural Finish	SF	x	x	x
Tactile Warning Strip	SF	x	x	x
Architectural Finish, Station Ancillary Space	SF	x	x	x
Station Agents' Booth	EA	x	x	x
Signage, Stations	STA	x	x	x
Station Furnishings, Platform (Allowance)	STA	x	x	x
MECHANICAL/ELECTRICAL				
Subsurface Ventilation, Tunnel	LF	x		
Air Distribution, Subsurface Ventilation	LF	x		
Fire Protection and Plumbing	LS	x	x	x
Station Power and Lighting (switches, equipment power, UPS, conduit and wiring, grounding)	FT2	x	x	x
Fire Alarm System	LS	x		
COMMUNICATION SYSTEMS				
Station Communications (PA, CCTV, Radio, fare vending)	STA	x	x	x

LEED IMPLEMENTATION (15% of Station Finishes and systems)	LS	x	x	x
Sawcut Asphalt or Concrete Pavement	LF	x	x	x
Miscellaneous Demolition - Crew	HR			
Finish Grading	SF		x	
Common Excavation	CY		x	
Structural Excavation	CY		x	
Backfill Material (imported)	CY		x	
Aggregate Base	CY	x	x	x
Trackway Underdrains	LF	x	x	x
Site / Roadway Drainage, Allowance	SY	x	x	x
Subballast	CY	x	x	x
CIPC, ADA Concrete Ramp w Railing	LS		x	
CIPC, Walls	CY		x	
CIPC, Platform Slab (Elevated)	CY		x	
CIPC, Miscellaneous Structures	CY	x	x	x
Station Canopy	SF		x	
Signage, Stations	STA	x	x	x
Station Shelters (Incl. benches, evap. cooling, etc.)	EA		x	x
Vending Machine Area (Allowance)	STA	x	x	x
Waterstops	LF	x		
Reinforcing Steel: Bridge	LBS			
Structure Concrete Bridge	CY			x
Structure Concrete Bridge Footing	CY			x
Bearing Pads	EA			x
Expansion Joint (MR??)	LF			x
Seismic Isolation Bearings	EA			x
Furnish Precast Concrete: Girder	LF			x
Install Precast Concrete: Girder	EA			x
Misc Metal	LBS	x	x	x

LF = linear foot, CF = cubic foot, SF = square foot, TF = track foot, RLF = route linear foot, VF = vertical foot, EA = each, LBS = pounds, HR= hour, CY = cubic yards, SY= square yards, LS = lump sum, STA = cost per station

In the station cost section, costs associated with joint development will be placed in the estimate, as warranted. Joint development items are costs associated with any income-producing activity with a transit nexus related to a real estate asset in which the project has an interest. Joint development projects are commercial, residential, industrial, or mixed-use developments that are induced by or enhance the effectiveness of transit projects.

4.3 SUPPORT FACILITIES: YARDS, SHOPS, ADMINISTRATION BUILDINGS (SCC 30)

Support facilities will include costs for:

- Rough grading, excavation, ventilation structures, equipment, traction power, facility power and lighting;
- Safety systems such as fire detection and prevention, security surveillance, access control, and life safety systems; and
- Finishes and equipment, including fueling stations.

Guideway and trackwork leading into and within the yard or maintenance facility will be included in this FTA SCC section. Support facility costs will be estimated on a unit basis for each type of facility and are listed below:

Line Item	Unit
Demolition	CY, SF
Earthwork	CY
Paving & Surfacing	SF, TON
Piped Utilities	LF, LS
Site Improvements	VARIOUS
Track Work	TF
Yard Electrical Work	LS
Traction Power	TF
Train Control	LS
Facilities Building Complete Incl. Electrical & Mechanical Work, Shop Equipment, Tools and Supplies	SF
Wheel Truer	EA
Blow Shed	EA
Service & Inspection Facility	EA
Car Wash Facility	EA
Running Repair, Component Change-out A/B Work, Support & Administrative	EA

4.4 SITEWORK & SPECIAL CONDITIONS (SCC 40)

Special condition costs will include capital costs for unique or non-typical elements as identified by the FTA SCC. These items are usually civil in nature and include items that are not part of the standard alignment costs and apply to either rail or bus alternatives. Site work and special conditions contain items that specifically address project-wide construction activities such as clearing, demolition, fine grading and other earthwork items outside the guideway limits. Sidewalks, paths, site and station furniture, signage, artwork, landscaping and permanent fencing, utility removal and modifications as well as environmental and hazardous material removal are included in this section. Special Conditions costs will be estimated on a per unit basis and the following items are examples of elements to be included in this capital cost category.

Line Item	**Unit**
Grading and excavation (outside the Guideway)	CY
Roadway Widening (Trackway)	SF
Park & Ride Lots	Spaces
Retaining Walls & Sound Walls	LF
Pedestrian Grade Crossings	Each
Mitigation Costs	LS
Hazardous Materials Removal	LS
Public Artwork	LS

Urban design cost items will be integrated as applicable into the special condition items. These elements include the physical treatment of the transit corridor between stations to provide a strong image and identity for transit and to promote a comfortable and cohesive streetscape that supports pedestrian movement and transit access. These items apply to both rail and non-rail fixed guideway alternatives.

Urban design elements that will be considered part of the streetscape program between stations include landscaping, decorative light standards, and special paving treatments. Urban design costs will be estimated as specific units as noted below. The specific items will be determined when the design and value engineering are completed. Urban Design items will be included Special Conditions category of the estimate and would typically include the following items:

Line Item	**Unit**
Integrated Street Tree, 48" Box	Each
Tree Grate, Cast Iron, Installed	Each
Ground Cover	SF
Decorative Lighting Fixture	Each
Paving	SF
Integral Color, Cast in Place, Scored	SF
Integral Color, Cast in Place, Sawcut/Sandblasted	SF

Special Conditions will also include utility costs for major relocation and modifications as a result of the guideway design. These utility costs are unique non-typical elements and will apply to both rail and non-rail fixed guideway alternatives. They are not part of the standard alignment costs that provide for minor utility and drainage adjustments, although these costs could be grouped under FTA Category 40.02. Utility costs will be estimated on a per unit basis. The following items are examples of elements to be included in this capital cost category:

Line Item	Unit
Storm Utilities (By Size & Type)	LF
Sewer Utilities (By Size & Type)	LF

4.5 SYSTEMS (SCC 50)

Systems costs will include the costs for the traction power distribution for train control and signals, traffic signal and crossing protection, traction power substations (catenary and third rail), communications, fare collection system and equipment and automated train control in a central control location.

For automated trains the competing technologies are either fixed block train control or advanced train control. Fixed block train control is widely used throughout the country on various transit systems. More advanced train control systems, such Alcatel used on BART, involve a mainframe computer and sophisticated software but have the best performance. For Train Control and Signals, the cost will include all signalizing and train control for the entire alternative, independent of the stations. The signal system costs will be estimated per route linear foot and interlocking and grade crossing signals will be on a per unit basis. This cost category includes the following items:

Line Item	Unit
Signal Systems	
Wayside, On-Board & Central	RLF
Control Hardware & Software	LS
Train Control Interlocking	EA
Grade Crossing Control Devices	EA
Flashing Lights and Gates	EA

Note: Route Linear Foot (RLF)

For Traffic Control and Signal protection the cost will include all traffic control and signal protection devices for the entire alternative including the stations. The signal system costs will be estimated based on location and type of signal to be installed. Included items are:

Line Item	Unit
Vehicular Traffic Signals	EA
Pedestrian Traffic Signals	EA
Pedestrian Crossings	EA

The traction power distribution for overhead catenary system costs will be estimated based on a system that may include a center pole or side pole and span wire systems. Installation and testing costs for all traction power distribution equipment are included in the unit cost numbers. Traction power distribution costs will be estimated on a route linear foot basis.

Line Item	Unit
Overhead Catenary System Poles, Foundations, Wires, Anchors, Testing	TF
Corrosion Protection	RLF

Substation costs will be estimated on a unit basis and include the following items: excavation, backfill, concrete slab, prefabricated substation, conduits, wiring, testing, parking, and architectural enhancements.

Communication and security costs items will include those elements attributable to the alignment, independent of any stations. Communication and security costs will be estimated on a route linear foot (RLF) basis when referring to the alignment work and lump sum (LS) when referring to the train control center. Standard items will include the following:

Line Item	Unit
Communication Power (Fiber Optics)	RLF
Testing	LS
Emergency Telephones	EA
Communication Power	LS
Radio Systems	LS

4.6 RIGHT-OF-WAY (SCC 60)

Right-of-way costs will include the capital costs for securing and providing all the property rights required for implementation of the project. These will include acquisition of property in fee or easement, as necessary, damages to remnant parcels, site clearing, building demolition, and relocation costs. Services to secure the right-of-way and contingency factors for right-of-way will be included as a multiplier to the right-of-way costs.

Right-of-way will be measured by area (square feet) at a parcel-by-parcel level, based on the proposed right-of-way and easement lines indicated on the conceptual plans for the project. Rates for right-of-way will be derived from the best available local data, such as sales and comparable acquisitions. The source of this information will be local real estate title companies, real estate professionals, and local appraisers. In special cases, such as existing developments, interviews may be held with property owners to understand specific characteristics of the property to help determine the fair market value. If necessary, costs for exercise of eminent domain will be included in the Right-of-Way cost section. In addition to right-of-way cost estimates, relocation costs will also be determined if parcels are occupied.

4.7 VEHICLES (SCC 70)

This item includes the cost of the estimated number of vehicles, either rail vehicles or buses, required under the proposed operational requirements of the system for each of the study alternatives. The vehicles are assumed to include the propulsion system, ventilation and air conditioning system, power collection devices and provisions for the disabled. The cost estimate for standard and articulated buses will assume bus types currently used in service. Vehicle costs will be estimated on a per unit basis.

5.0 UNIT PRICES

Unit prices for non-rail and rail fixed guideway systems will be used to develop the planning and conceptual cost estimates. The unit prices will be developed and compiled from non-rail and rail fixed guideway projects around the country and will be referenced in 4th quarter 2005 dollars.

Included in the unit prices will be cost allocations for minor utility relocation, mobilization/ demobilization, traffic control and risk management, as appropriate. Each cross section will have a specific percentage applied to reflect expected change in utility relocation, traffic control, etc. Because these items can vary by cost parameter and by location along the alignment, the percentage allocation also varies. The following is a description of these items:

- Utility Allowance -- Cost of relocating minor utilities, estimated as one percent of the line item cost.
- Mobilization/Demobilization -- Overhead costs of the construction forces to provide and subsequently remove equipment, personnel, and facilities for the project. A six percent allowance for this item is typical and will be used for costing purposes.
- Traffic Control -- Cost to provide for public traffic circulation through the construction site. This item is especially applicable within the in-street segments of the alignment and at-grade crossings. Maintenance of traffic is estimated at two percent of the line item cost and will be used for cost estimating purposes.

6.0 CONTINGENCIES

A project contingency is an allowance for items and conditions which cannot be assessed at the time of preparation of the cost estimate, due to the level of design in a particular phase of the Project.

Contingencies are needed for two reasons. First, because the work is not identified in extensive detail in the early stages of conceptual design and project elements may be overlooked. Second, work tends to be added as the design is refined, more design reviews occur or regulatory procedures become stricter. As a result, there are four types of contingencies which need to be applied to the project cost: the Design/Estimating Contingency, Construction Change Order Contingency, Vehicle Contingency, and Right-of-Way Contingency. Also, a project reserve is typically included.

6.1 DESIGN/ ESTIMATING CONTINGENCY

The design/estimating contingency is allocated directly to the FTA SCC items in Section 10 through 50. The design/estimating contingency ranges from 5-35 percent at conceptual stage and is applied to all SCC line items. The percentage varies based on several factors:

- Risk in the level of design, and
- Quantities and estimated accuracy for each item.

These contingencies decline as a project becomes better defined during design development. They are intended to compensate for ultimate project cost requirements and provide an estimate of capital costs for real budgetary purposes. High contingency percentages are applied to planning level studies, with the percentages decreasing as the project moves into conceptual engineering. The contingency percentages further decline as the project moves into preliminary engineering and final design. The contingency would approach 10 percent at the 100 percent contract document stage and would remain until the project is in the bidding phase. This allows for adjustments to unit prices to reflect market conditions and timing of contract award. Contingency should reflect the degree of risk associated with the level of design detail available and the characteristics of the specific design element.

6.2 CONSTRUCTION CHANGE ORDER CONTINGENCY

As noted above, the design/estimating contingency percentage decreases as the project design detail increases. The capital cost estimate for a contract package can then be compared to contractors' bids. However, during construction, a construction contingency will also be needed for change orders during construction. The Change Order Contingency is included as part of the soft cost multiplier applied to FTA SCC 80.04 Construction Administration & Management.

6.3 VEHICLE CONTINGENCY

The costs of rail transit vehicles, buses or other vehicle types do not contain the level of hidden costs that may be associated with a construction item. However, the cost of vehicles may vary because of the availability of specific components for the vehicle, the number of vehicles ordered, and the type and number of design features required. Recent vehicle cost data will serve as the basis for estimating vehicle costs for this project, with a 10 percent contingency added to account for unforeseen costs associated with vehicle fleet procurement. The contingency percentages vary based on the items listed under SCC 70.00.

6.4 RIGHT-OF-WAY CONTINGENCY

A contingency factor also needs to be applied to right-of-way costs so that sufficient funds are identified to secure the necessary right-of-way. The suggested contingency is 40 percent and is necessary to cover damage and negotiation contingencies as noted below.

1. A Damage Contingency is needed to provide for compensation for damages, which might occur in the event that a relatively small area of land acquisition is necessary, but the impact to the remainder of the parcel is felt to be high by the property owner. The Damage Contingency is recommended at 20 percent.

2. Negotiation Contingency is needed to accurately reflect the cost of right-of-way as consecutive parcels enter into negotiation. If the initial property owners successfully negotiate a high acquisition price, subsequent property owners may use that value to increase their compensation. A 20 percent contingency factor is recommended to have sufficient funds for negotiation.

6.5 PROJECT RESERVE

Project Reserve is an unallocated contingency. The other construction contingencies are assignable to SCC items in FTA Section 10 through 50 and vary based on level of cost and design information. Project Reserve is the only true contingency that is unknown at this stage of project development and is based on the entire project subtotal. A project reserve of eight percent will be applied to the project cost estimate for elements outside of the normal assigned contingency ranges. This cost will be shown in FTA SCC 90 Unallocated Contingency.

7.0 PROFESSIONAL SERVICES (COST ESTIMATE MULTIPLIERS OR SOFT COSTS)

FTA SCC professional services or "soft costs" are allowances based upon percentages of the construction and procurement costs which must be included in the project costs. Data from transit properties throughout the United States will be reviewed to determine the costs of specific items. A percentage of the actual capital cost will then be derived. The projects to be considered include systems completed and in operation, in final design and entering into construction, and some in the planning and conceptual engineering stages.

Generally, the cost multipliers range from about 20 percent to 40 percent. Historically, this variance was attributable to the type of corridor within which the system was constructed and the method of contracting (e.g., Design-Bid-Build or Design-Build). Systems utilizing mixed-use right-of-way alignments, e.g., street/median/dedicated, experienced the higher cost multipliers previously mentioned. For example, the Guadalupe and Tasman Corridor Projects in San Jose, California and Los Angeles' Green Line, had soft costs in excess of 50 percent. The sample estimate multipliers are approximately 25 percent and are representative of a $1.4 billion capital cost estimate. The proposed construction cost multipliers will be discussed with the City and, if necessary, an estimate approach will be developed based on a detailed list of staff, facilities and equipment. The following is a breakdown of the FTA soft costs with a sample of the proposed percentages.

7.1 PROFESSIONAL SERVICES COST MULTIPLIERS

Conceptual and Preliminary Engineering, including design costs and design services during construction .... 8 percent

Final Design, including design costs and design services during construction .... 10 percent

Project Management for Design and Construction .... 6 percent

Construction Administration & Management .... 10 percent

Insurance (Owner Controlled Insurance Program, or O.C.I.P.) .... 2 percent

Legal Permits; Review Fees by other agencies, etc. .... 1 percent

Survey Testing, Investigation, and Inspection .... 1 percent

Agency Force Account Work .... 2 percent

7.2 VEHICLE COST MULTIPLIER

The vehicle procurement process requires both design and agency costs. The costs are expressed as percentages or multipliers based on the vehicle capital cost. The project multiplier is within the range of 14 to 17 percent for design, procurement and agency costs. Thus, a multiplier of 17 percent is recommended for use in the estimate detail for vehicles.

7.3 RIGHT-OF-WAY MULTIPLIER

Engineering, Appraisal, and Condemnation Costs provide for professional engineering services, agency staff services, property appraisal, and legal fees for condemnation proceedings, if required, for the acquisition of project right-of-way. This multiplier is recommended at 10 percent and is suggested for use in the estimate detail for right-of-way.

8.0 SAMPLE COST ESTIMATE

Figure 1 provides an example of how the cost estimates will be developed for the various transit alternatives. The figure lists the ten major cost estimate parameters from Guideway through Finance Costs, with example quantities and unit costs. The Construction Total in this example is $750.1 million and includes contingency. The capital cost in the example is $1.4 billion and includes escalation.

An approximate escalation rate as published by ENR or other similar resource will be used to estimate a rate to apply to the midpoint of construction. In the example the estimated escalation rate is 3 percent.

MAJOR TUNNEL PROJECT WEST COAST — DRAFT

Central Subway TBM Method — Last Rev 1/3/06 4:47 PM

Preliminary 4 th Street Alignment

Ref #		Description	Quantity	Units	Unit Cost with contingency	Subtotal Cost Without Contigency	Cont.	7-05 Estimate Subtotal Cost With Contigency (2005$)
10.00		**GUIDEWAY & TRACK ELEMENTS**						
	10.01	Guideway: At-grade Exclusive Right-of-way	NOT USED	-	$0	$0	0%	$0
	10.02	Guideway: At-grade Semi-exclusive (Allows cross-traffic)	537	TF	$240	$107,400	20%	$128,880
	10.03	Guideway: At-grade in mixed traffic	NOT USED	-	$0	$0	0%	$0
	10.04	Guideway: Aerial structure	NOT USED	-	$0	$0	0%	$0
	10.05	Guideway: Built-up fill	NOT USED	-	$0	$0	0%	$0
	10.06	Guideway: Underground cut & cover	1,038	RF	$33,092	$28,624,926	20%	$34,349,911
	10.07	Guideway: Underground tunnel	5,987	RF	$29,108	$151,540,761	15%	$174,271,875
	10.08	Guideway: Retained cut or fill	361	RF	$7,422	$2,232,785	20%	$2,679,342
	10.09	Track: Direct fixation	16,272	TF	$475	$6,721,232	15%	$7,729,417
	10.10	Track: Embedded	1,074	TF	$873	$815,166	15%	$937,441
	10.11	Track: Ballasted	NOT USED	-	$0	$0	0%	$0
	10.12	Track: Special (switches, turnouts)	4	EA	$920,755	$3,202,625	15%	$3,683,019
	10.13	Track: Vibration and noise dampening	1,000	TF	$994	$864,000	15%	$993,600
		SUBTOTAL COST GUIDEWAY & TRACK ELEMENTS				$194,108,895		$224,773,485
20.00		**STATIONS, STOPS, TERMINALS, INTERMODAL (3 Underground)**						
	20.01	At-grade station, stop, shelter, mall, terminal, platform		STA	$0	$0	20%	$0
	20.02	Aerial station, stop, shelter, mall, terminal, platform	NOT USED	-	$0	$0	0%	$0
	20.03	Underground station, stop, shelter, mall, terminal, platform	3	STA	$113,395,442	$283,488,604	20%	$340,186,325
	20.04	Other stations, landings, terminals: Intermodal, ferry, trolley, etc.	NOT USED	-	$0	$0	0%	$0
	20.05	Joint development	1	0	$0	$0	20%	$0
	20.06	Automobile parking multi-story structure	NOT USED	-	$0	$0	0%	$0
	20.07	Elevators, escalators	24	EA	$901,900	$18,037,990	20%	$21,645,588
		SUBTOTAL COST STATIONS				$301,526,594		$361,831,913
30.00		**YARDS, SHOPS, ADMIN/SUPPORT FACILITIES (acres)**						
	30.01	Administration Building: Office, sales, storage, revenue counting	NOT USED	-	$0	$0	0%	$0
	30.02	Light Maintenance Facility	NOT USED	-	$0	$0	0%	$0
	30.03	Heavy Maintenance Facility	NOT USED	-	$0	$0	0%	$0
	30.04	Storage or Maintenance of Way Building	NOT USED	-	$0	$0	0%	$0
	30.05	Yard and Yard Track	NOT USED	-	$0	$0	0%	$0
		SUBTOTAL COST YARDS, SHOPS, ADMIN, ETC				$0		$0
40.00		**SITEWORK & SPECIAL CONDITIONS**						
	40.01	Demolition, Clearing, Earthwork	1	Allow	$6,308,466	$4,672,938	35%	$6,308,466
	40.02	Site Utilities, Utility Relocation	1	LS	$20,017,098	$16,013,678	25%	$20,017,098
	40.03	Haz. mat'l, contam'd soil removal/mitigation, ground water treatments	1	LS	$2,616,360	$2,093,088	25%	$2,616,360
	40.04	Environmental mitigation, e.g. wetlands, historic/archeologic, parks	NOT USED	-	$0	$0	0%	$0
	40.05	Site structures including retaining walls, sound walls	NOT USED	-	$0	$0	0%	$0
	40.06	Pedestrian/bike access and accommodation, landscaping	1	LS	$3,677,566	$14,796,746	20%	$15,409,674
	40.07	Automobile, bus, van accessways including roads, parking lots	NOT USED	-	$0	$0	0%	$0
	40.08	Temporary facilities and other indirect costs during construction	1	LS	$16,882,576	$14,068,813	20%	$16,882,576
		SUBTOTAL COST SITEWORK & SPECIAL CONDITIONS				$51,645,263		$61,234,173
50.00		**SYSTEMS**						
	50.01	Train control and signals	1	LS	$27,036,222	$22,530,185	20%	$27,036,222
	50.02	Traffic signals and crossing protection	1	LS	$1,386,457	$1,155,381	20%	$1,386,457
	50.03	Traction power supply: substations	2	EA	$11,373,792	$18,956,320	20%	$22,747,584
	50.04	Traction power distribution: catenary and third rail	8,673	RF	$1,918	$14,467,883	15%	$16,638,065
	50.05	Communications	1	LS	$25,832,630	$21,527,192	20%	$25,832,630
	50.06	Fare collection system and equipment	1	LS	$3,156,900	$2,630,750	20%	$3,156,900
	50.07	Central Control	1	LS	$5,450,272	$4,541,893	20%	$5,450,272
		SUBTOTAL COST SYSTEMS				$85,809,604		$102,248,131
		CONSTRUCTION SUBTOTAL				$633,090,356		$750,087,702
60.00		**ROW, LAND, EXISTING IMPROVEMENTS (acres)**						
	60.01	Purchase or lease of real estate	1	LS	$18,000,000	$13,846,154	30%	$18,000,000
	60.02	Relocation of existing households and businesses	1	LS	$2,000,000	$1,538,461	30%	$2,000,000
		SUBTOTAL COST ROW, LAND, EXISTING IMPROVEMENTS				$15,384,615		$20,000,000
70.00		**VEHICLES (4 ea Articulated)**						
	70.01	Light Rail	4	ea	$4,070,552	$14,802,008	10%	$16,282,209
	70.02	Heavy Rail	NOT USED	-	$0	$0	0%	$0
	70.03	Commuter Rail	NOT USED	-	$0	$0	0%	$0
	70.04	Bus	NOT USED	-	$0	$0	0%	$0
	70.05	Other	NOT USED	-	$0	$0	0%	$0
	70.06	Non-revenue vehicles	1	LS	$0	$0	20%	$0
	70.07	Spare parts (10% of LRV's)	4	LS	$222,030	$740,100	20%	$888,120
		Subtotal Cost VEHICLES (4 ea Articulated)				$15,542,108		$17,170,329
80.00		**PROFESSIONAL SERVICES**						
	80.01	Preliminary Engineering	5.00%		$750,087,702	$37,504,385	N/A	$37,504,385
	80.02	Final Design	6.00%		$750,087,702	$45,005,262	N/A	$45,005,262
	80.03	Project Management for Design and Construction	3.50%		$750,087,702	$26,253,070	N/A	$26,253,070
	80.04	Construction Administration & Management	5.50%		$750,087,702	$41,254,824	N/A	$41,254,824
	80.05	Insurance	1.00%		$750,087,702	$7,500,877	N/A	$7,500,877
	80.06	Legal, Permits, Review Fees by other agencies, cities, etc	1.00%		$750,087,702	$7,500,877	N/A	$7,500,877
	80.07	Survey, Testing, Investigation, Inspection	1.00%		$750,087,702	$7,500,877	N/A	$7,500,877
	80.08	Agency: Force Account Work (2%)	2.00%		$750,087,702	$15,001,754	N/A	$15,001,754
		Subtotal PROFESSIONAL SERVICES				$187,521,925		$187,521,925
			25.00%					
						SubTotal 10-80		$974,779,956
90.00		**UNALLOCATED CONTINGENCY (10 - 80)**	8%					77,982,396
100.00		**FINANCE CHARGES**						$100,000,000
		Total Construction (10+20+30+40+50) (2005$)						$750,087,702
		TOTAL PROJECT COST (60+70+80+90+100) (2005$)						$1,152,762,352
		Escalation (Thru 4 th Qtr '13) @ 3% annually						$244,687,648
TOTAL PROJECT COST (WITH ESCALATION)								$1,397,450,000
								$1,397,450,000

Date: 01/03/06 — SHEET 1 OF 1

Honolulu High-Capacity Transit Corridor Project

Operating and Maintenance Cost Estimating Methodology Report

June 30, 2006

Prepared for:
City and County of Honolulu

Prepared by:
Lea+Elliott, Inc.

Under Subcontract to:
Parsons Brinckerhoff Quade & Douglas, Inc.

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Executive Summary

The City and County of Honolulu (City), in cooperation with the Federal Transit Administration (FTA), is initiating an Alternatives Analysis (AA), leading to preparation of a Draft Environmental Impact Statement (DEIS), to identify and evaluate high capacity transit service improvements along a corridor between Kapolei and the University of Hawaiʻi at Mānoa (UH Mānoa).

The scope of this current work entails detailed planning and conceptual engineering of transit alternatives, and culminates in the selection by the City Council of a locally preferred alternative (LPA) and the development of several documents to be submitted to the FTA, one of which is the Alternatives Analysis Report. In preparing an Alternatives Analysis for this project, a methodology will be developed to estimate the operations and maintenance costs of the various alternatives analyzed.

This Final Operations and Maintenance (O&M) Cost Estimating Methodology Report is a supporting document to information provided in the Alternatives Analysis Report. It describes the approach that will be used in estimating O&M costs - the resource build-up approach, which is a disaggregate method allowing the evaluation of costs in great detail - which is consistent with the approach required by the FTA.

The model will be developed using Microsoft® Excel to estimate annual labor and non-labor O&M costs through the year 2030 for each of the transit modes defined by the study alternatives, and will determine future costs in 2006 dollars using operating data output from the service level model. Employing a cost model based upon this resource build-up approach will sufficiently estimate O&M costs for each of the alternatives defined in the alternatives analysis.

O&M cost estimates for each of the alternatives will be an important part of the cost effectiveness and local financial commitment criteria used in the evaluation of alternatives leading to the selection of the locally preferred alternative. The O&M cost estimates will also comprise part of the project justification criteria submitted to the FTA for its review and ultimate rating of the project.

1 Introduction

The City and County of Honolulu (City), in cooperation with the Federal Transit Administration (FTA), is initiating an Alternatives Analysis (AA), leading to preparation of a Draft Environmental Impact Statement (DEIS), to identify and evaluate high capacity transit service improvements along a corridor between Kapolei and the University of Hawai‘i at Mānoa (UH Mānoa) as shown in Figure 1-1.

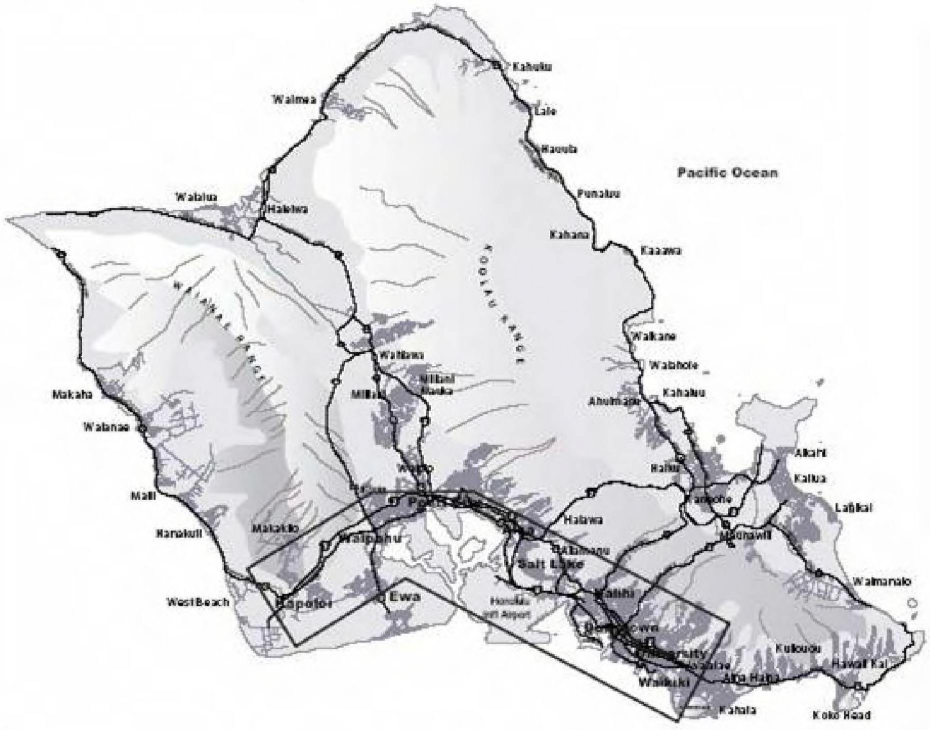

Figure 1-1: Honolulu High-Capacity Transit Corridor

The scope of this current work entails detailed planning and conceptual engineering of transit alternatives, and culminates in the selection by the City Council of a locally preferred alternative (LPA) and the development of several documents to be submitted to the FTA, one of which is the Alternatives Analysis Report. In preparing an Alternatives Analysis for this project, a methodology will be developed to estimate the operations and maintenance costs of the various alternatives analyzed.

1.1 Purpose of this Report

This report is one of a number of reports required by the AA Study that will be produced for the general purpose of providing early information to the FTA and others interested in the project's procedures and findings.

The purpose of this O&M Cost Estimating Methodology Report is to summarize and document the process by which O&M cost estimates will be developed for each of the detailed alternatives to be defined. This will primarily involve describing the way in which the O&M cost model will be developed, validated and used.

2 Existing Transit Service

2.1 Section Purpose

This section provides an overview of public transit service as it currently exists on the island of O'ahu. This overview serves as a point of reference in the context of developing O&M cost estimates for proposed alternative transit services defined by the Alternatives Analysis.

2.2 Organization

Public transit on the island of O'ahu is the responsibility of the City and County of Honolulu, Department of Transportation Services (DTS).

DTS plans, designs, operates and maintains transportation systems; locates, selects, installs and maintains traffic control facilities, devices and street lighting systems; approves plans and designs for construction, reconstruction and widening of public streets and roads; promulgates rules and regulations for the use of streets and roadways; and manages the City's contract for bus and paratransit operations, which is performed by O'ahu Transit Services (OTS), a private, non-profit corporation that operates and maintains TheBus and TheHandi-Van systems (the System).[1]

2.3 System

The service area for the System encompasses the island of O'ahu, which is approximately 600 square miles, with a population of about 836,000. Almost all of the transit capacity is provided within the urbanized area of Honolulu (containing a population of about 720,000) via motor bus and paratransit service. Operating data, as reported by DTS to the FTA National Transit Database (NTD) for the 2005 reporting year, is provided in Appendix A to further describe the System.

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[1] *Department of Transportation Services*. August 2003. City and County of Honolulu. 13 October 2005 <http://www.co.honolulu.hi.us/budget/cityorganization/dts.htm>.

3 O&M Cost Estimating Methodology Overview

3.1 General Approach

The flowchart in Figure 3-1 provides an overview of the steps to be taken to develop O&M costs. The initial phase of the process will involve performing a preliminary operations analysis necessary to identify an operating plan for each alternative. These operating plans, together with the development of other technical data, will constitute the detailed definition of the alternatives.

Once the detailed definition of alternatives has been established, work will then proceed concurrently along two paths. One path will involve the analysis of service and demand levels necessary to develop a final operating plan for each alternative, which optimizes its performance. Finalizing the operating plan will involve detailed transit network coding, analyses of service levels, travel forecasting, and demand/supply equilibration, and will culminate in the development of a variety of estimates for operating parameters (e.g., vehicle-miles, vehicle-hours, peak number of vehicles) that will drive the O&M cost model.

The other path will involve the development of the O&M cost model itself, which will be performed in the following sequence, and correlates to the steps shown in Figure 3-1:

- **Collection and Analysis of Data.** A detailed budget statement and an accurate estimate of service characteristics from a recent stable and representative fiscal year of DTS and OTS will be collected and analyzed. Data will also be collected and analyzed from representative U.S. transit properties for alternatives that include transit modes new to the study area. Where possible, the National Transit Database will also be used as a source in collecting and analyzing information.
- **Calibration of the Model.** The O&M cost model will then be calibrated by identifying those costs that are variable with service levels, and attributing each variable cost item to the service characteristic to which it is most closely tied. The resulting unit costs will then be applied to the service characteristics for each alternative to estimate the O&M cost of the alternative.
- **Validation of the Model.** The O&M cost model will be subsequently validated by applying it to a past fiscal year in which service levels were somewhat different and examining how well the estimated costs match the actual expenditures for that year.

Once the model is validated and estimates of the relevant operating variables that serve as input to the model are developed, the model will be applied to determine O&M costs for the study alternatives. The application of the O&M cost model to future service years and/or transit modes will be straightforward: the service requirements for each alternative - vehicle-miles, for example - will be used in the model to estimate labor and material costs for that alternative. The results will be documented in the O&M Cost Estimating Memorandum on a line-item basis for each alternative so that the source of cost difference(s) between the options can be examined.

In summary, the O&M cost model will reflect historic operations, anticipate future operations, and address all functional responsibilities of the transit property. It will also focus on major cost components, apply consistent levels of service data, apply peer transit property experience, apply readily available information, provide fully-allocated costs for use in cost-effectiveness analysis, be structured for sensitivity analyses, and document the model theory and application.[2]

3.2 Overview of Major Model Components

The resource build-up model approach relies on a number of critical elements, including the following:

- Productivity Ratios
- Unit Costs
- Driving Variables

Productivity ratios describe how labor and materials vary with service levels. These are typically expressed as measures such as "gallons of fuel per vehicle mile", or "number of mechanics per vehicle mile". Unit costs are the estimated costs per unit of service or material required, for example "annual wage per mechanic", or "average cost per gallon of fuel". Driving variables are defined as those that most strongly influence the cost of a particular line item and will be identified for each line item cost. For example, annual revenue bus vehicle-hours will be assumed to be primarily responsible for the cost of bus operators' wages, while annual revenue LRT vehicle-miles would be assumed to be most influential in determining the amount of LRT vehicle maintenance materials and supplies.

[2] *Estimation of Operating and Maintenance Costs for Transit Systems*. Washington, D.C.: Technology Sharing Program, U.S. Department of Transportation, 1992.

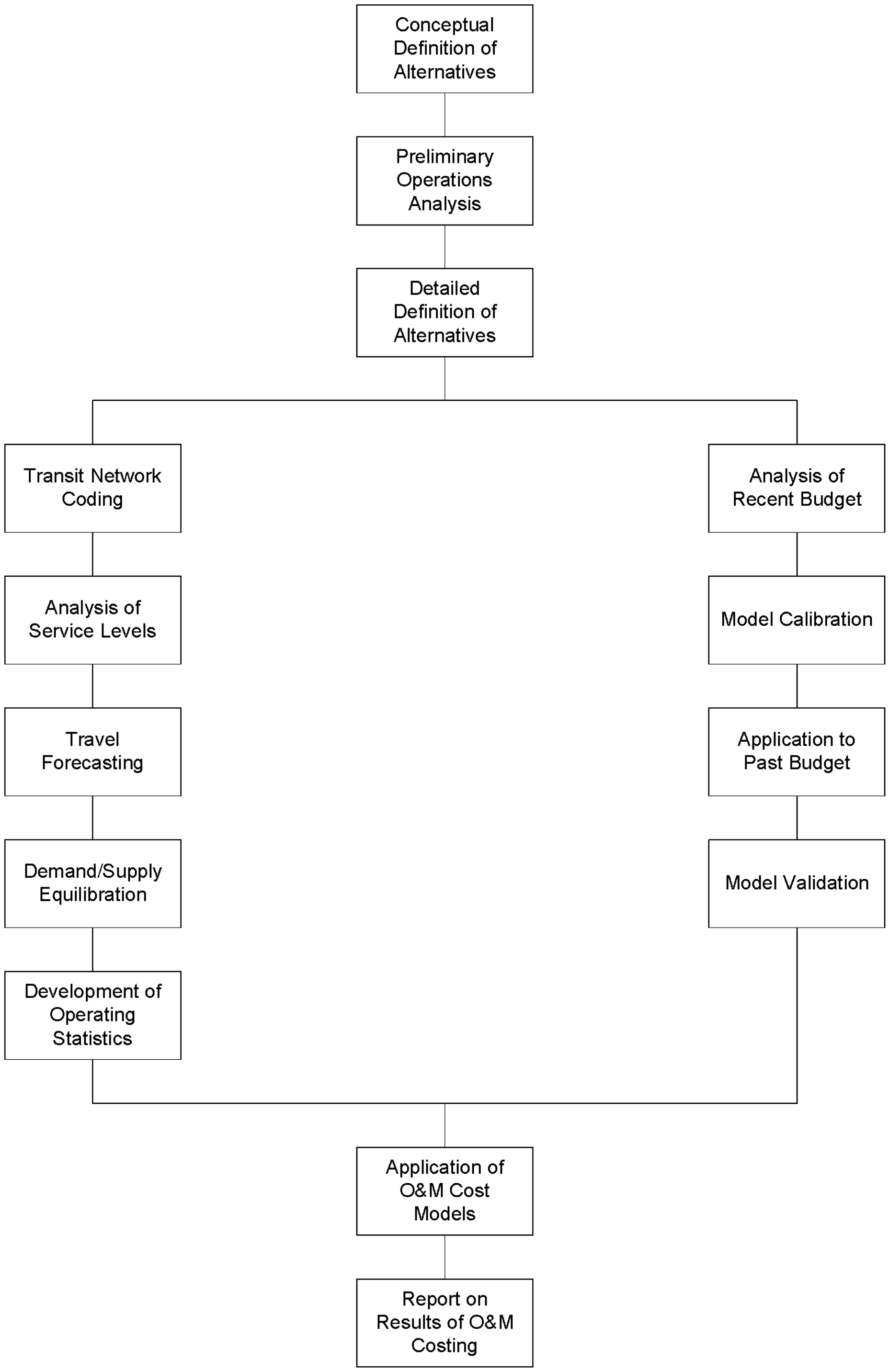

Figure 3-1: Estimating Operating and Maintenance Costs[3]

[3] This figure was based on a similar figure in the following reference: *Procedures and Technical Methods For Transit Project Planning, Part II, Chapter 4, Operating and Maintenance Costs*. Washington, D.C.: Federal Transit Administration, 1990.

4 Detailed O&M Cost Estimating Methodology

4.1 Collecting and Analyzing Data

4.1.1 Bus

Bus operating and financial data will be obtained from DTS, OTS, and, as required, from the National Transit Database (NTD). The data will be collected from detailed budget statements and operating reports from a recent, stable, and representative year for the System. For example, a 34-day strike by OTS bus operators in August 2003 significantly impacted operating and financial data for NTD report year 2004. This would not be considered to be a representative year since the values for variables such as vehicle hours, vehicle miles, annual passengers, platform hours, etc. will be significantly different than a typical year. Data from fiscal year 2004-2005 (NTD report year 2005) will therefore be collected, as this is the most recent and representative year of data.

4.1.2 Rail

Rail operating and financial data will be obtained from peer rail property budgets, the NTD, and other data sources such as the American Public Transit Association (APTA), as required. As with the bus data, rail data will be collected from detailed budget statements and operating reports for a recent and stable year. This data will be obtained from representative rail properties that most closely match the Honolulu environment (if possible), and the proposed service characteristics and rail modes defined for the HHCTC by the alternatives.

4.2 Calibrating the Model

The resource build-up approach to estimating O&M costs, a disaggregate method allowing the evaluation of costs in great detail, will be utilized in developing the O&M cost model, which is consistent with the approach required by the FTA[4]

The O&M cost model will be sufficiently documented to permit simple verification of the assumptions and sources of information used. Every equation and every coefficient in each resource build-up equation will be clearly referenced, including the source of the information used.

In using the resource build-up approach, the model will compute O&M labor and material costs for each mode by calculating unit costs from existing budget and operating data, then applying the unit costs to estimated future operating scenarios.

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[4] *Procedures and Technical Methods For Transit Project Planning, Part II, Chapter 8, Financial Planning for Transit*. Washington, D.C.: Federal Transit Administration, 2003.

Each line item within the model will be assigned a driving variable, which will be the factor that most strongly influences a change in the item's annual cost. Expenses will be modeled as a function of OTS's calibration-year cost, and the calibration-year and future values of the driving variable. It will be implicitly assumed that current rates of consumption and labor productivity will continue into the future.

The general formulae that will be used in this resource build-up model include the following:

Non-Labor:

$$\textit{Annual Non-Labor Cost} = \textit{Total Base Cost} \div \textit{Base Driving Variable} \times \textit{Future Driving Variable}$$

where, *Total Base Cost* is the actual non-labor expense for the calibration-year; *Base Driving Variable* is the value of the calibration-year driving variable that most strongly influences a cost item; and *Future Driving Variable* is the future-year input value of the driving variable as defined by the service level model for a particular alternative.

Labor:

$$\textit{Annual Labor Cost} = \textit{Future Driving Variable} \times \textit{Labor Productivity Rate} \times \textit{Annual Cost Per Employee}$$

where, *Future Driving Variable* is the future-year input value of the driving variable defined by the alternatives analysis[5] ; *Labor Productivity Rate* is the number of positions divided by the *Base Driving Variable*; and *Annual Cost Per Employee* is the average annual earnings, including salary, vacation, holiday, and sick pay, not including fringes such as medical insurance, pension, and social security.

A single O&M cost model will be developed that accounts for transit services currently provided, as well as for those services required by each of the alternatives. Direct costs for each mode will be projected separately within the model, with indirect (overhead) costs allocated among the modes based on capacity miles operated, or other factors as necessary.

Each labor and non-labor cost item for all OTS divisions and departments related to transit operations will be modeled. The model will be based on OTS's current organizational structure, staffing plans, labor productivity, and non-labor consumption rates. Where the model cannot be based on OTS's data as described herein (e.g., transit operations labor for a

[5] Note that the *Future Driving Variable* will be substituted with the *Base Driving Variable* (the value of the calibration-year driving variable) in initially calculating productivity rates.

fully-automated system), it will be based on similar data obtained from the associated peer property for the mode defined by the respective alternative.

Because operator wages and benefits typically constitute 50 percent or more of total operating costs, specific line items will be included for each unique labor position (e.g., operator, mechanic, etc.) and non-labor expense (e.g., energy (fuel), parts, etc.) for the operations division.

OTS operates diesel motor buses in its demand response (paratransit) operation, and diesel motor bus and hybrid electric motor bus in its standard bus operations. OTS contracts for demand response service. Contracted demand response costs will be calculated as a percentage of total O&M costs since these costs tend to fluctuate with the size of a transit system. The model will be developed to differentiate between buses by size (articulated (60 ft.), standard (40 ft.), and neighborhood shuttles/vans (30-35 ft.)), by energy source (diesel, hybrid, CNG, fuel cell, etc.), where applicable, and between rail technologies as defined by each of the alternatives, e.g., high capacity AGT, LRT, HR, etc. O&M costs associated with all current and planned maintenance facilities will also be estimated.

Based on OTS's calibration-year budgeted expenses, organizational structure, service levels, job classifications, and wage rates, the model will be developed in the steps described in the subsections below.

4.2.1 Identify Driving Variables

The first step in model calibration will be to identify the driving variables and their values that describe current (calibration-year) operations. The variable that most strongly influences the particular cost will be assigned for each of the line items in OTS's detailed budget. For example, the cost of bus operator wages is most strongly influenced by the variable, "annual vehicle revenue hours". The calibration-year driving variable value will be used to establish the productivity rate that will be used, in part, in estimating future costs.

The driving variables identified for the calibration year above will also be used as input variables that will drive the estimation of costs for every item in the model. The values of these inputs will be defined by the operating plans associated with each of the alternatives analyzed, and will be used with the productivity rate discussed above in the equation that estimates O&M costs.

This same approach will be employed in identifying driving variables and values associated with each of the rail peer properties' detailed budgets.

A variable may apply to bus, rail, or both. The driving variables that will be used in the model are summarized by mode in Table 4-1, and described thereafter.

Table 4-1: Driving Variables for the O&M Cost Model

Driving Variable	Bus	Rail
Operating		
Annual Unlinked Passenger Trips	X	X
Bus Routes / Rail Lines	X	X
Vehicles Operated in Maximum Service	X	X
Maintenance Facilities	X	X
Annual Vehicle Revenue Miles	X	X
Annual Vehicle Revenue Hours	X	X
Directional Route Miles		X
Passenger Stations		X
Financial		
Capacity Miles	X	X
Salary Adjustment Factor	X	X
Fringe Rate - Bargaining, Salaried Employees	X	X
Fringe Rate - Bargaining, Hourly Employees	X	X
Fringe Rate - Non-Bargaining Employees	X	X
Alternate Year	X	X

Operating Driving Variables:

Unlinked Passenger Trips. The number of passengers who board public transportation vehicles. Passengers are counted each time they board vehicles no matter how many vehicles they use to travel from their origin to their destination. OTS served approximately 68.1 million passengers in NTD reporting year 2005.

Bus Routes / Rail Lines. The number of directly-operated scheduled fixed bus routes, or number of rail lines defined as train service, operating continuously in a unique corridor. OTS currently operates approximately 90 bus routes.

Vehicles Operated in Maximum Service. The number of revenue vehicles operated to meet the annual maximum service requirement. This is the revenue vehicle count during the peak season of the year; on the week and day that maximum service is provided. For the 2005 NTD reporting year, OTS operated 516 buses in maximum service. Vehicles operated in maximum service exclude:

- atypical days, or
- one-time special events.

Maintenance Facilities. Facilities where maintenance activities are conducted including garages, shops (e.g., body, paint, and machine) and operations centers. OTS currently operates out of four bus maintenance garages.

Vehicle Revenue-Miles. The miles that vehicles are either scheduled to travel, or actually travel, while in revenue service. For the 2005 NTD reporting year, OTS operated approximately 22.4 million vehicle-revenue miles. Vehicle revenue-miles include miles associated with:

- layover / recovery time.

Vehicle revenue-miles exclude miles associated with:

- deadheading;
- operator training; and
- vehicle maintenance testing; as well as
- school bus and charter services.

Vehicle Revenue-Hours. The hours that vehicles are either scheduled to travel, or actually travel, while in revenue service. For the 2005 NTD reporting year, OTS operated approximately 1.65 million vehicle revenue-hours. Vehicle revenue-hours include:

- layover / recovery time.

Vehicle revenue-hours exclude time associated with:

- deadheading;
- operator training; and
- vehicle maintenance testing; as well as
- school bus and charter services.

Directional Route-Miles. The mileage in each direction over which public transportation vehicles travel while in revenue service. Directional route-miles are:

- a measure of the route path over a facility or roadway, not the service carried on the facility; e.g., number of routes, vehicles, or vehicle revenue-miles; and are
- computed with regard to direction of service, but without regard to the number of traffic lanes or rail tracks existing in the right-of-way (ROW).

Directional route-miles do not include staging or storage areas at the beginning or end of a route.

The base value for this variable in determining the productivity rate will be obtained from OTS data for the bus model, and for the rail model from operating statistics of the peer rail property associated with the alternative being analyzed. The future value for this variable will be obtained for a given alternative from the specific definition of the alternative in the alternatives analysis.

Passenger stations. A passenger boarding / deboarding facility with a platform, which may include:

- stairs;
- elevators;
- escalators;
- passenger controls (e.g., faregates or turnstiles);
- canopies;
- wind shelters;
- lighting;
- signs; and
- a building with a waiting room, ticket office or machines, restrooms, or concessions. Includes all fixed guideway passenger facilities (except for on-street cable car and light rail stops), including busway passenger facilities; underground, at grade, and elevated rail stations; and ferryboat terminals. Includes transportation / transit / transfer centers, park-and-ride facilities, and transit malls with the above components, including those only utilized by motor buses.

This variable does not include stops (which are typically on-street locations at the curb or in a median, sometimes with a shelter, signs, or lighting) for:

- bus;
- light rail; or
- cable car.

The base value for this variable in determining the productivity rate will be obtained from the peer rail property operating statistics required by the associated alternative. The future value for this variable will be obtained for a given alternative from the specific definition of the alternative in the alternatives analysis.

Financial Driving Variables:

Bus Capacity-Miles. The percentage of total transit capacity-miles allocated to bus service.

Rail Capacity-Miles. The percentage of total transit capacity miles allocated to rail service.

Salary Adjustment. A variable used to adjust wages and salaries based on system size. This factor will be a fixed percentage for each additional peak bus or peak rail vehicle operated and will typically apply to staff directly involved in managing the operation.

Fringe Rate - Bargaining, Salaried Employees. The average fringe benefit rate of bargaining, salaried employees in the operations division. Fringe benefits include social security, Medicare, pension, life and medical insurance, uniform allowances, and workers compensation. Sick, holiday, vacation and other paid leave are included as base wages.

Fringe Rate - Bargaining, Hourly Employees. The average fringe benefit rate of bargaining, hourly employees in the operations division.

Fringe Rate - Non-Bargaining Employees. The average fringe benefit rate of non-bargaining employees in the operations division.

Alternate Year. A variable used to adjust 2006, model-generated O&M costs to future or past-year dollars. This will be used in the validation of the model to compare model-estimated costs to actual costs of the calibration year.

Past experience has shown that certain operating statistics generated by the travel demand forecasting model may be inaccurate due to the number of simplifying assumptions made (e.g., rounding) in developing the model, thereby resulting in overestimates of these operating statistics. As a result, annual vehicles operated in maximum service, annual vehicle revenue hours, and annual vehicle revenue miles will be calculated independently for each of the alternatives, based on the service frequency, travel time, and distance of each bus route and/or rail line. These variables will be validated by comparing estimated values for the no-build alternative with that of DTS's current operations.

Future non-revenue operations such as report, layover and deadhead time, and distance, as well as scheduled and unscheduled overtime, will be implicitly assumed to increase at current proportions. For example, if OTS's scheduled overtime hours is 2% of annual scheduled operator hours, this same ratio would be assumed for all future alternatives.

4.2.2 Determine Labor Costs

Labor costs will be determined using the following formula or a variation thereof:

$$\begin{array}{c} \textit{Annual} \\ \textit{Labor} \\ \textit{Cost} \end{array} = \begin{array}{c} \textit{Future} \\ \textit{Driving} \\ \textit{Variable} \end{array} \times \begin{array}{c} \textit{Labor} \\ \textit{Productivity} \\ \textit{Rate} \end{array} \times \begin{array}{c} \textit{Annual} \\ \textit{Cost Per} \\ \textit{Employee} \end{array}$$

where, *Future Driving Variable* is the input value for a given alternative of the future-year driving variable as defined by the alternatives analysis (this will be substituted with the *Base Driving Variable* (the value of the calibration-year driving variable) in initially calculating productivity rates); *Labor Productivity Rate* is the number of positions divided by the *Base Driving Variable*; and *Annual Cost Per Employee* is the average annual earnings, including salary, vacation, holiday, and sick pay, excluding fringe benefits such as medical insurance, pension, and social security.

For example, in determining the labor cost of full-time bus operators based on an alternative yielding an input variable of 750,000 revenue bus-hours per year, the model will estimate annual bus operator labor costs as follows:

The productivity rate will first be calculated by dividing the number of budgeted positions for full-time bus operators of 250 by the calibration-year annual revenue bus-hours of 550,000. The productivity rate would be .000454545 (250/550,000).

The estimated annual labor cost would then be calculated using the formula, as follows:

Annual Labor Cost	=	*Future Driving Variable*	X	*Labor Productivity Rate*	X	*Annual Cost Per Employee*
$ 11.9M	=	750,000	X	.000454545	X	$ 35,000

This example reflects an increase in annual bus operator labor costs from $8.75M (550,000 X 250) to $11.9M as a result of the increase in annual revenue bus hours from 550,000 to 750,000, thereby requiring 341 full-time bus operators ($11.9/$35,000). This is an increase of 91 operators (341-250).

Actual data will be different from the data used in this example, and will be based on OTS's budget, operating characteristics, and data yielded by the travel demand forecasting model for each of the alternatives.

Labor costs will be modeled in one of two ways, based on whether the position is an operations position or a support position. For the operations division, every position will be modeled by job classification, listing the base earnings and fringe benefit rate for each. Base earnings include sick, holiday, vacation, and other paid absences, including sick leave time reimbursement. Fringe benefit rates will account for overtime, workers compensation, social security, pension, and insurance. Positions will be distinguished as hourly vs. salaried.

For each support division, labor positions, earnings and fringe benefit rates will be aggregated by the model into a single line item.

4.2.3 Determine Non-Labor Costs

Non-labor costs will be determined using the following formula:

$$\textit{Annual Non-Labor Cost} = \textit{Total Base Cost} \div \textit{Base Driving Variable} \times \textit{Future Driving Variable}$$

where, *Total Base Cost* is the actual non-labor expense for the calibration-year; *Base Driving Variable* is the value of the calibration-year driving variable that most strongly influences a cost item; and *Future Driving Variable* is the input value of the future-year driving variable for a specific alternative as defined by the alternatives analysis.

For example, the annual cost of bus parts would be estimated as follows:

The total annual base cost of bus parts will be, for the purpose of this example, $2M, and the number of peak vehicles, 50, is the base driving variable, which is the variable that most strongly influences the annual cost of parts (both of these data are obtained from the information collected from DTS). The future driving variable will be 60 vehicles, which is defined by the particular alternative. The formula would then be applied as follows:

Annual Non-Labor Cost	=	*Total Base Cost*	÷	*Base Driving Variable*	X	*Future Driving Variable*
$ 2.4M	=	$ 2M	÷	50	X	60

This example reflects that as a result of an increase in the number of peak vehicles by 10 to 60, the annual total cost of bus parts would increase by $400,000 to $2.4M.

Actual data will be different from the data used in this example, and will be based on OTS's budget, operating characteristics, and data yielded by the travel demand forecasting model for each of the alternatives.

Non-labor costs will be generally designated as services, material, energy (fuel), utilities, travel, lease, casualty, and miscellaneous, and will be aggregated by cost type for most departments, but modeled in greater detail for the operations division.

4.2.4 Build Line Item Detail Table

The line item detail table contains the model itself, which is primarily the productivity ratios and unit costs determined from detailed OTS budgetary and operating data, and from the representative peer rail properties. Outputs from the model will be the labor requirements (staffing), if any, for each category, and the estimated costs.

Labor and non-labor items will be grouped together by department, with labor items listed first. The detail will describe the category, driving variable, productivity ratio, and unit cost for each category; and the estimated staffing and costs for the service characteristics associated with the specific alternative being analyzed. An example line item detail table is shown in Table 4-2.

Rail traction power costs will be calculated according to estimated vehicle power consumption based on the service defined by the alternative, and the rates for usage and demand charged by the local power utility in Honolulu. This will be reflected in the line item detail table on a summary basis linked to a separate worksheet containing the respective detailed data and calculations.

4.3 Validating the Model

Once the model is calibrated, it will be validated by entering service characteristic data for up to two past (known) fiscal OTS years to determine if the model estimates staffing levels and costs that are nearly the same as the actual data for the past years. The service levels of the past years will ideally be somewhat different than the calibration year service levels. Any significant variations in the estimates compared to that of the actual data will be analyzed, explained, and where applicable, resolved.

4.4 Determining O&M Costs for the Alternatives

Determining O&M costs for each of the alternatives will be straightforward. The operating requirements for each alternative will be entered into the model to estimate the staffing levels and labor and material costs, as described previously.

Two O&M cost estimates will be generated for each alternative. The first will always be the cost, in 2006 dollars, to operate and maintain the existing DTS bus system at a specified level of service for the year defined by the alternative. The second will be the cost, also in 2006 dollars, to operate and maintain the particular transit system defined by the alternative. For example, that could be a light rail transit system with modified feeder bus service, or it could be a light rail transit system with modified feeder bus service in one location and standard bus route service (as with the existing System) at another location.

Table 4-2: Example O&M Cost Model Line Item Detail Table[6]

1 acct	2 resource category	3 driving variable	4 productivity ratio	5 unit cost	6 staff	7 cost (000)
010	office of director of operations	peak veh	1 staff per 200 peak veh	$47,000 per staffer		
	schedulers	peak veh	1 staff per 65 peak veh	$28,700 per staffer		
	shift supervisor	garage	3 supervisors per garage	$38,400 per supervisor		
	street supervisor	veh-hr	1 supervisor per .14MM veh-hr	$34,100 per supervisor		
	support staff	garage	5 staff per garage	$22,000 per staffer		
032	fuel	veh-mi	.31 gal per veh-mil	$.94 per gal	NA	
	lubrication	veh-mi	--	$.012 per veh-mi	NA	

[6] *Procedures and Technical Methods For Transit Project Planning, Part II, Chapter 4, Operating and Maintenance Costs.* Washington, D.C.: Federal Transit Administration, 1990.

1 acct	2 resource category	3 driving variable	4 productivity ratio	5 unit cost	6 staff	7 cost (000)
033	tires and tubes	veh-mi	--	$.021 per veh-mi	NA	
042	office of director of maintenance	peak veh	1 staff per 250 peak veh	$38,000 per staffer		
	maintenance supervisors	garage	3 supervisors per garage	$36,200 per supervisor		
	support staff	garage	2 staff per garage	$22,000 per staffer		

4.5 Presenting the Data

The output data of the model will be presented in the Memorandum on O&M Cost Estimating Results, with summary tables describing each of the alternatives, the values of their input variables, and the values of the outputs for staffing requirements and costs. Additional summary tables organizing this information according to department and cost type (e.g., labor, services, utilities, etc.) will also be provided. Detailed tables incorporating all data for each of the alternatives will also be developed for use as required.

5 Conclusion

The alternatives analysis study is intended to provide information to local officials on the benefits, costs, and impacts of alternative transportation investments developed to address the purpose and need for a transportation improvement in the corridor. The ultimate outcome of the study is the selection of a locally preferred alternative from the list of defined alternatives.

In support of this, each of the alternatives will be evaluated according to a set of criteria collectively referred to as project justification and local financial commitment criteria, which generally include 1) mobility improvements; 2) cost-effectiveness; 3) environmental benefits; 4) operating efficiencies; 5) transit supportive land use; 6) local financial commitment; and 7) other factors such as environment justice considerations and equity issues; opportunities for increased access to employment for low income persons and welfare to work initiatives; livable communities initiatives and local economic development initiatives; and consideration of innovative financing, procurement, and construction techniques, including design-build turnkey applications.

O&M cost estimates for each of the alternatives will be an important part of the cost effectiveness and local financial commitment criteria used in the evaluation of alternatives leading to the selection of the locally preferred alternative. The O&M cost estimates will also comprise part of the project justification criteria submitted to the FTA for its review and ultimate rating of the project.

References

Department of Transportation Services. August 2003. City and County of Honolulu. 13 October 2005 <http://www.co.honolulu.hi.us/budget/cityorganization/dts.htm>.

Estimation of Operating and Maintenance Costs for Transit Systems. Washington, D.C.: Technology Sharing Program, U.S. Department of Transportation, 1992.

Procedures and Technical Methods For Transit Project Planning, Part II, Chapter 4, Operating and Maintenance Costs. Washington, D.C.: Federal Transit Administration, 1990.

Procedures and Technical Methods For Transit Project Planning, Part II, Chapter 8, Financial Planning for Transit. Washington, D.C.: Federal Transit Administration, 2003.

DTS 2005 NTD - Agency Profile Data

	Bus (TheBus)	Demand Response (TheHandi-Van)	Total
Vehicles Operated in Maximum Service	416	100	516
Vehicle Peak to Base Ratio	1.56	NA	NA
Average Fleet Age in Years	7.3	4.7	NA
Annual Vehicle Revenue Miles	18,388,911	4,035,830	22,424,741
Annual Vehicle Revenue Hours	1,365,082	283,396	1,648,478
Annual Unlinked Trips	67,406,827	733,777	68,140,604
Annual Passenger Miles	291,109,916	8,966,697	300,076,613
Service Efficiency			
Operating Expense per Vehicle Revenue Mile	$ 6.91	$ 4.25	NA
Operating Expense per Vehicle Revenue Hour	$ 93.08	$ 60.58	NA
Cost Effectiveness			
Operating Expense per Passenger Mile	$ 0.44	$ 1.91	NA
Operating Expense per Unlinked Passenger Trip	$ 1.89	$ 23.40	NA
Service Effectiveness			
Unlinked Passenger Trips per Vehicle Revenue Mile	3.67	0.18	NA
Unlinked Passenger Trips per Vehicle Revenue Hour	49.38	2.59	NA

DTS 2005 NTD - Operating Expenses by Function (in 000's)

	Bus (TheBus)	Demand Response (TheHandi-Van)	Total
Vehicle Operations	$ 79,491	$ 11,932	$ 91,423
Vehicle Maintenance	$ 26,309	$ 1,977	$ 28,286
Non-Vehicle Maintenance	$ 3,262	$ 297	$ 3,559
General Administration	$ 18,007	$ 2,963	$ 20,970
Total	$ 127,069	$ 17,169	$ 144,238

DTS 2005 NTD - Operating Expenses by Object Class (in 000's)

	Bus (TheBus)	Demand Response (TheHandi-Van)	Total
Operators' Wages	$ 36,550	$ 6,371	$ 42,921
Other Salaries and Wages	$ 21,517	$ 2,534	$ 24,051
Fringe Benefits	$ 37,211	$ 4,305	$ 41,516
Services	$ 2,973	$ 547	$ 3,520
Material and Supplies - Fuel and Lube	$ 9,398	$ 1,056	$ 10,454
Material and Supplies - Tires and Other	$ 8,099	$ 852	$ 8,951
Utilities	$ 1,198	$ 66	$ 1,264
Casualty and Liability	$ 7,638	$ 1,108	$ 8,746
Taxes	$ 2,283	$ 231	$ 2,514
Purchased Transportation	$ 0	$ 0	$ 0
Other	$ 202	$ 100	$ 302
Total	$ 127,069	$ 17,169	$ 144,283

DTS 2005 NTD - Operators' Wages

	Bus (TheBus)
Operating Time - Dollars (in 000's)	
Platform Time	$ 30,941
Straight Time Allowances	$ 1,949
Premium Time	$ 2,798
Non-Operating Paid Work Time	$ 862
Total Amount	$ 36,550
Operating Time - Hours (in 000's)	
Platform Time	1,509
Straight Time Allowances	97
Premium Time	273
Non-Operating Paid Work Time	62
Total Hours	1,941

DTS 2005 NTD - Energy Consumption (in 000's)

	Bus (TheBus)	Demand Response (TheHandi-Van)	Total
Gallons of Diesel Fuel	6,383	641	7,025

DTS 2005 NTD - Employee Work Hours and Counts

	Bus (TheBus)	Demand Response (TheHandi-Van)	Total
Employee Work Hours			
Vehicle Operations	2,106,803	422,989	2,529,792
Vehicle Maintenance	516,671	43,426	560,097
Non-Vehicle Maintenance	65,831	7,185	73,016
General Administration	196,096	39,715	235,811
Total Operating	2,885,401	513,315	3,398,716
Actual Employee Count			
Vehicle Operations	1,013	224	1,237
Vehicle Maintenance	301	27	328
Non-Vehicle Maintenance	36	6	42
General Administration	111	22	133
Total Operating	1,461	279	1,740

DTS 2005 NTD - Service Supplied and Consumed

	Bus (TheBus)	Demand Response (TheHandi-Van)	Total
Vehicles Available for Maximum Service	525	123	648
Service Supplied (in 000's)			
Annual Scheduled Vehicle Revenue Miles	18,474	0	18,474
Annual Vehicle Miles	21,558	5,014	26,572
Annual Vehicle Revenue Miles	18,389	4,036	22,425
Annual Vehicle Hours	1,493	354	1,847
Annual Vehicle Revenue Hours	1,365	283	1,648
Service Consumed (in 000's)			
Unlinked Passenger Trips	67,407	734	68,141
Passenger Miles	291,110	8,967	300,077

DTS 2005 NTD - Maintenance Facilities

	Bus (TheBus)	Demand Response (TheHandi-Van)	Total
General Purpose - Under 200 Vehicles	0	1	1
General Purpose - 200 to 300 Vehicles	2	0	2
Heavy Maintenance	1	0	1
Total	3	1	4

DTS 2005 NTD - Transit Way Mileage

	Bus (TheBus)
Lane Miles	
Exclusive Right-of-Way	1
Controlled Right-of-Way	35
Directional Route Miles	
Exclusive Right-of-Way	1
Controlled Right-of-Way	35
Mixed Traffic	883

DTS 2005 NTD - Age Distribution of Active Vehicle Inventory

	Articulated Bus (60 ft.)	Bus (40 ft.)	Vans (20-35 ft.)
Years			
5 or less	60	120	88
6 to 11	0	213	51
12 to 15	0	67	12
16 to 20	0	0	0
Summary			
Total Active Fleet	60	400	151
Average Age of Fleet (in Years)	3.2	7.9	5.4

Honolulu High-Capacity Transit Corridor Project

Operating and Maintenance Cost Estimating Methodology Report

June 30, 2006

Prepared for:
City and County of Honolulu

Prepared by:
Lea+Elliott, Inc.

Under Subcontract to:
Parsons Brinckerhoff Quade & Douglas, Inc.

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Executive Summary

The City and County of Honolulu (City), in cooperation with the Federal Transit Administration (FTA), is initiating an Alternatives Analysis (AA), leading to preparation of a Draft Environmental Impact Statement (DEIS), to identify and evaluate high capacity transit service improvements along a corridor between Kapolei and the University of Hawaiʻi at Mānoa (UH Mānoa).

The scope of this current work entails detailed planning and conceptual engineering of transit alternatives, and culminates in the selection by the City Council of a locally preferred alternative (LPA) and the development of several documents to be submitted to the FTA, one of which is the Alternatives Analysis Report. In preparing an Alternatives Analysis for this project, a methodology will be developed to estimate the operations and maintenance costs of the various alternatives analyzed.

This Final Operations and Maintenance (O&M) Cost Estimating Methodology Report is a supporting document to information provided in the Alternatives Analysis Report. It describes the approach that will be used in estimating O&M costs - the resource build-up approach, which is a disaggregate method allowing the evaluation of costs in great detail - which is consistent with the approach required by the FTA.

The model will be developed using Microsoft® Excel to estimate annual labor and non-labor O&M costs through the year 2030 for each of the transit modes defined by the study alternatives, and will determine future costs in 2006 dollars using operating data output from the service level model. Employing a cost model based upon this resource build-up approach will sufficiently estimate O&M costs for each of the alternatives defined in the alternatives analysis.

O&M cost estimates for each of the alternatives will be an important part of the cost effectiveness and local financial commitment criteria used in the evaluation of alternatives leading to the selection of the locally preferred alternative. The O&M cost estimates will also comprise part of the project justification criteria submitted to the FTA for its review and ultimate rating of the project.

1 Introduction

The City and County of Honolulu (City), in cooperation with the Federal Transit Administration (FTA), is initiating an Alternatives Analysis (AA), leading to preparation of a Draft Environmental Impact Statement (DEIS), to identify and evaluate high capacity transit service improvements along a corridor between Kapolei and the University of Hawai'i at Mānoa (UH Mānoa) as shown in Figure 1-1.

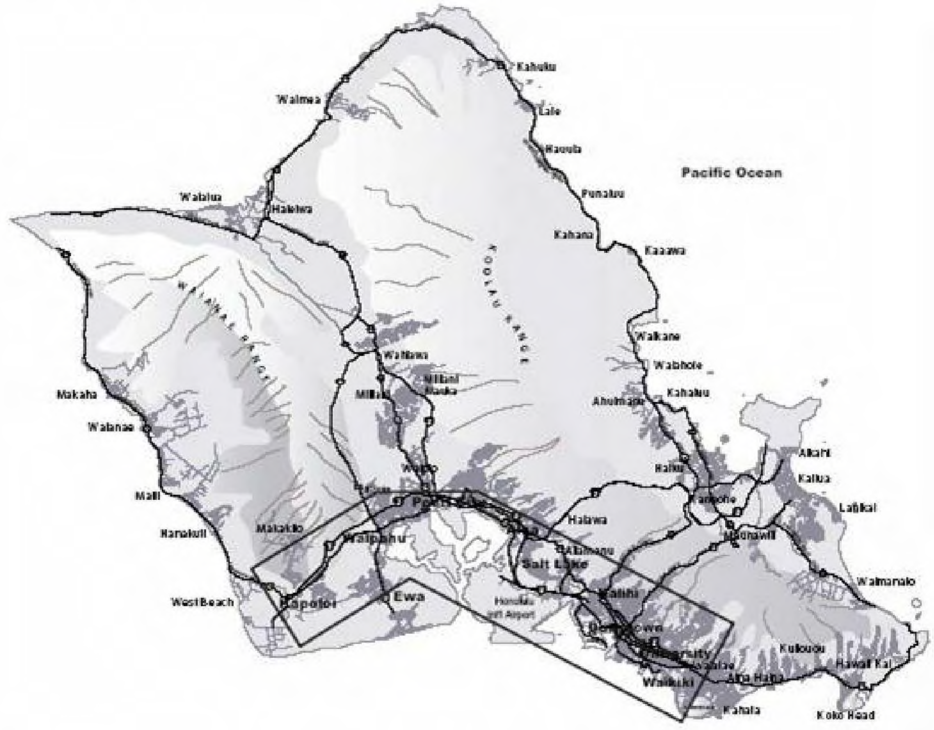

Figure 1-1: Honolulu High-Capacity Transit Corridor

The scope of this current work entails detailed planning and conceptual engineering of transit alternatives, and culminates in the selection by the City Council of a locally preferred alternative (LPA) and the development of several documents to be submitted to the FTA, one of which is the Alternatives Analysis Report. In preparing an Alternatives Analysis for this project, a methodology will be developed to estimate the operations and maintenance costs of the various alternatives analyzed.

1.1 Purpose of this Report

This report is one of a number of reports required by the AA Study that will be produced for the general purpose of providing early information to the FTA and others interested in the project's procedures and findings.

The purpose of this O&M Cost Estimating Methodology Report is to summarize and document the process by which O&M cost estimates will be developed for each of the detailed alternatives to be defined. This will primarily involve describing the way in which the O&M cost model will be developed, validated and used.

2 Existing Transit Service

2.1 Section Purpose

This section provides an overview of public transit service as it currently exists on the island of O'ahu. This overview serves as a point of reference in the context of developing O&M cost estimates for proposed alternative transit services defined by the Alternatives Analysis.

2.2 Organization

Public transit on the island of O'ahu is the responsibility of the City and County of Honolulu, Department of Transportation Services (DTS).

DTS plans, designs, operates and maintains transportation systems; locates, selects, installs and maintains traffic control facilities, devices and street lighting systems; approves plans and designs for construction, reconstruction and widening of public streets and roads; promulgates rules and regulations for the use of streets and roadways; and manages the City's contract for bus and paratransit operations, which is performed by O'ahu Transit Services (OTS), a private, non-profit corporation that operates and maintains TheBus and TheHandi-Van systems (the System).[1]

2.3 System

The service area for the System encompasses the island of O'ahu, which is approximately 600 square miles, with a population of about 836,000. Almost all of the transit capacity is provided within the urbanized area of Honolulu (containing a population of about 720,000) via motor bus and paratransit service. Operating data, as reported by DTS to the FTA National Transit Database (NTD) for the 2005 reporting year, is provided in Appendix A to further describe the System.

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[1] *Department of Transportation Services*. August 2003. City and County of Honolulu. 13 October 2005 <http://www.co.honolulu.hi.us/budget/cityorganization/dts.htm>.

3 O&M Cost Estimating Methodology Overview

3.1 General Approach

The flowchart in Figure 3-1 provides an overview of the steps to be taken to develop O&M costs. The initial phase of the process will involve performing a preliminary operations analysis necessary to identify an operating plan for each alternative. These operating plans, together with the development of other technical data, will constitute the detailed definition of the alternatives.

Once the detailed definition of alternatives has been established, work will then proceed concurrently along two paths. One path will involve the analysis of service and demand levels necessary to develop a final operating plan for each alternative, which optimizes its performance. Finalizing the operating plan will involve detailed transit network coding, analyses of service levels, travel forecasting, and demand/supply equilibration, and will culminate in the development of a variety of estimates for operating parameters (e.g., vehicle-miles, vehicle-hours, peak number of vehicles) that will drive the O&M cost model.

The other path will involve the development of the O&M cost model itself, which will be performed in the following sequence, and correlates to the steps shown in Figure 3-1:

- **Collection and Analysis of Data.** A detailed budget statement and an accurate estimate of service characteristics from a recent stable and representative fiscal year of DTS and OTS will be collected and analyzed. Data will also be collected and analyzed from representative U.S. transit properties for alternatives that include transit modes new to the study area. Where possible, the National Transit Database will also be used as a source in collecting and analyzing information.
- **Calibration of the Model.** The O&M cost model will then be calibrated by identifying those costs that are variable with service levels, and attributing each variable cost item to the service characteristic to which it is most closely tied. The resulting unit costs will then be applied to the service characteristics for each alternative to estimate the O&M cost of the alternative.
- **Validation of the Model.** The O&M cost model will be subsequently validated by applying it to a past fiscal year in which service levels were somewhat different and examining how well the estimated costs match the actual expenditures for that year.

Once the model is validated and estimates of the relevant operating variables that serve as input to the model are developed, the model will be applied to determine O&M costs for the study alternatives. The application of the O&M cost model to future service years and/or transit modes will be straightforward: the service requirements for each alternative - vehicle-miles, for example - will be used in the model to estimate labor and material costs for that alternative. The results will be documented in the O&M Cost Estimating Memorandum on a line-item basis for each alternative so that the source of cost difference(s) between the options can be examined.

In summary, the O&M cost model will reflect historic operations, anticipate future operations, and address all functional responsibilities of the transit property. It will also focus on major cost components, apply consistent levels of service data, apply peer transit property experience, apply readily available information, provide fully-allocated costs for use in cost-effectiveness analysis, be structured for sensitivity analyses, and document the model theory and application.[2]

3.2 Overview of Major Model Components

The resource build-up model approach relies on a number of critical elements, including the following:

- Productivity Ratios
- Unit Costs
- Driving Variables

Productivity ratios describe how labor and materials vary with service levels. These are typically expressed as measures such as "gallons of fuel per vehicle mile", or "number of mechanics per vehicle mile". Unit costs are the estimated costs per unit of service or material required, for example "annual wage per mechanic", or "average cost per gallon of fuel". Driving variables are defined as those that most strongly influence the cost of a particular line item and will be identified for each line item cost. For example, annual revenue bus vehicle-hours will be assumed to be primarily responsible for the cost of bus operators' wages, while annual revenue LRT vehicle-miles would be assumed to be most influential in determining the amount of LRT vehicle maintenance materials and supplies.

[2] *Estimation of Operating and Maintenance Costs for Transit Systems*. Washington, D.C.: Technology Sharing Program, U.S. Department of Transportation, 1992.

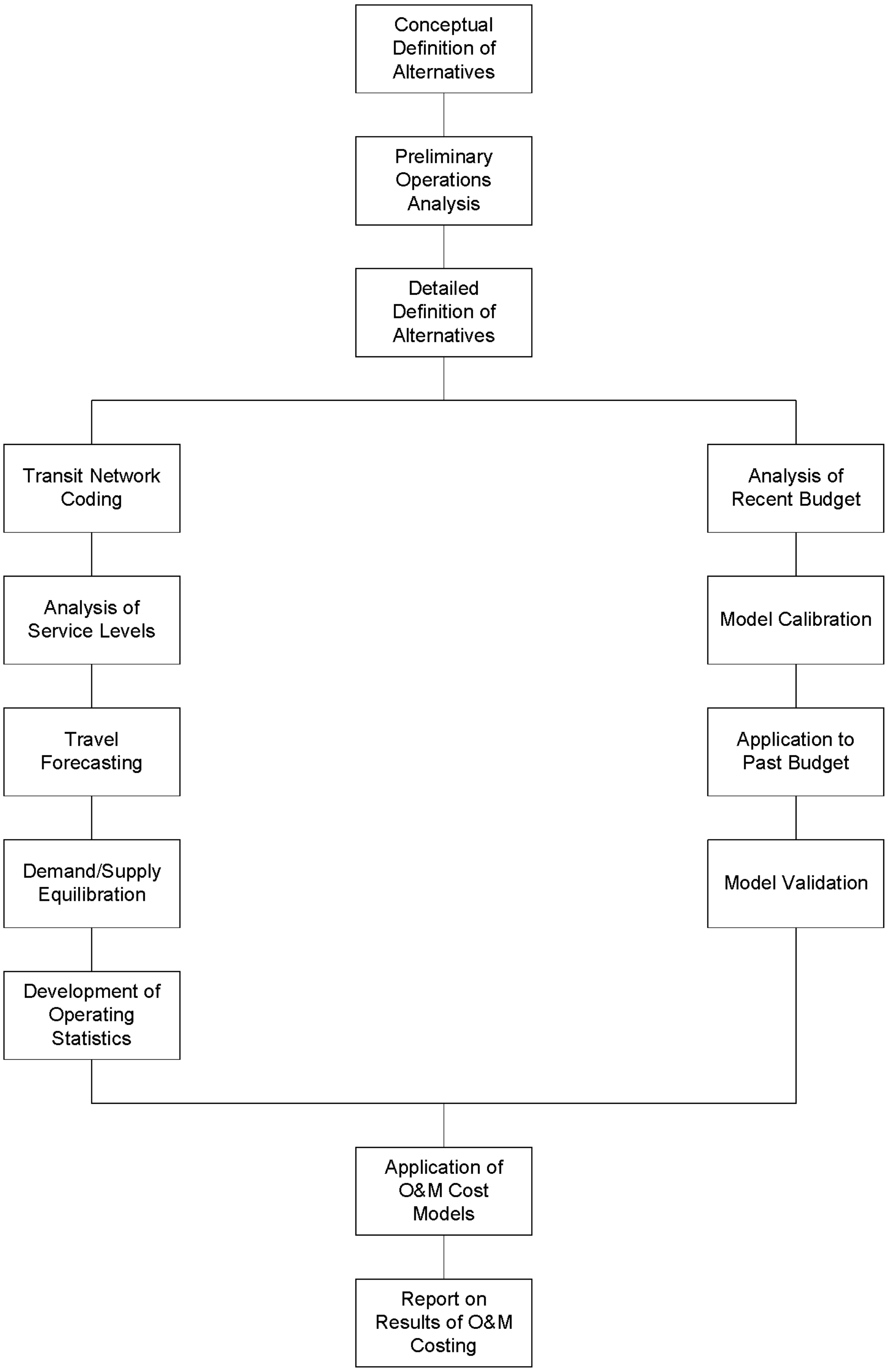

Figure 3-1: Estimating Operating and Maintenance Costs[3]

[3] This figure was based on a similar figure in the following reference: *Procedures and Technical Methods For Transit Project Planning, Part II, Chapter 4, Operating and Maintenance Costs*. Washington, D.C.: Federal Transit Administration, 1990.

4 Detailed O&M Cost Estimating Methodology

4.1 Collecting and Analyzing Data

4.1.1 Bus

Bus operating and financial data will be obtained from DTS, OTS, and, as required, from the National Transit Database (NTD). The data will be collected from detailed budget statements and operating reports from a recent, stable, and representative year for the System. For example, a 34-day strike by OTS bus operators in August 2003 significantly impacted operating and financial data for NTD report year 2004. This would not be considered to be a representative year since the values for variables such as vehicle hours, vehicle miles, annual passengers, platform hours, etc. will be significantly different than a typical year. Data from fiscal year 2004-2005 (NTD report year 2005) will therefore be collected, as this is the most recent and representative year of data.

4.1.2 Rail

Rail operating and financial data will be obtained from peer rail property budgets, the NTD, and other data sources such as the American Public Transit Association (APTA), as required. As with the bus data, rail data will be collected from detailed budget statements and operating reports for a recent and stable year. This data will be obtained from representative rail properties that most closely match the Honolulu environment (if possible), and the proposed service characteristics and rail modes defined for the HHCTC by the alternatives.

4.2 Calibrating the Model

The resource build-up approach to estimating O&M costs, a disaggregate method allowing the evaluation of costs in great detail, will be utilized in developing the O&M cost model, which is consistent with the approach required by the FTA[4]

The O&M cost model will be sufficiently documented to permit simple verification of the assumptions and sources of information used. Every equation and every coefficient in each resource build-up equation will be clearly referenced, including the source of the information used.

In using the resource build-up approach, the model will compute O&M labor and material costs for each mode by calculating unit costs from existing budget and operating data, then applying the unit costs to estimated future operating scenarios.

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[4] *Procedures and Technical Methods For Transit Project Planning, Part II, Chapter 8, Financial Planning for Transit*. Washington, D.C.: Federal Transit Administration, 2003.

Each line item within the model will be assigned a driving variable, which will be the factor that most strongly influences a change in the item's annual cost. Expenses will be modeled as a function of OTS's calibration-year cost, and the calibration-year and future values of the driving variable. It will be implicitly assumed that current rates of consumption and labor productivity will continue into the future.

The general formulae that will be used in this resource build-up model include the following:

Non-Labor:

$$\textit{Annual Non-Labor Cost} = \textit{Total Base Cost} \div \textit{Base Driving Variable} \times \textit{Future Driving Variable}$$

where, *Total Base Cost* is the actual non-labor expense for the calibration-year; *Base Driving Variable* is the value of the calibration-year driving variable that most strongly influences a cost item; and *Future Driving Variable* is the future-year input value of the driving variable as defined by the service level model for a particular alternative.

Labor:

$$\textit{Annual Labor Cost} = \textit{Future Driving Variable} \times \textit{Labor Productivity Rate} \times \textit{Annual Cost Per Employee}$$

where, *Future Driving Variable* is the future-year input value of the driving variable defined by the alternatives analysis[5] ; *Labor Productivity Rate* is the number of positions divided by the *Base Driving Variable*; and *Annual Cost Per Employee* is the average annual earnings, including salary, vacation, holiday, and sick pay, not including fringes such as medical insurance, pension, and social security.

A single O&M cost model will be developed that accounts for transit services currently provided, as well as for those services required by each of the alternatives. Direct costs for each mode will be projected separately within the model, with indirect (overhead) costs allocated among the modes based on capacity miles operated, or other factors as necessary.

Each labor and non-labor cost item for all OTS divisions and departments related to transit operations will be modeled. The model will be based on OTS's current organizational structure, staffing plans, labor productivity, and non-labor consumption rates. Where the model cannot be based on OTS's data as described herein (e.g., transit operations labor for a

[5] Note that the *Future Driving Variable* will be substituted with the *Base Driving Variable* (the value of the calibration-year driving variable) in initially calculating productivity rates.

fully-automated system), it will be based on similar data obtained from the associated peer property for the mode defined by the respective alternative.

Because operator wages and benefits typically constitute 50 percent or more of total operating costs, specific line items will be included for each unique labor position (e.g., operator, mechanic, etc.) and non-labor expense (e.g., energy (fuel), parts, etc.) for the operations division.

OTS operates diesel motor buses in its demand response (paratransit) operation, and diesel motor bus and hybrid electric motor bus in its standard bus operations. OTS contracts for demand response service. Contracted demand response costs will be calculated as a percentage of total O&M costs since these costs tend to fluctuate with the size of a transit system. The model will be developed to differentiate between buses by size (articulated (60 ft.), standard (40 ft.), and neighborhood shuttles/vans (30-35 ft.)), by energy source (diesel, hybrid, CNG, fuel cell, etc.), where applicable, and between rail technologies as defined by each of the alternatives, e.g., high capacity AGT, LRT, HR, etc. O&M costs associated with all current and planned maintenance facilities will also be estimated.

Based on OTS's calibration-year budgeted expenses, organizational structure, service levels, job classifications, and wage rates, the model will be developed in the steps described in the subsections below.

4.2.1 Identify Driving Variables

The first step in model calibration will be to identify the driving variables and their values that describe current (calibration-year) operations. The variable that most strongly influences the particular cost will be assigned for each of the line items in OTS's detailed budget. For example, the cost of bus operator wages is most strongly influenced by the variable, "annual vehicle revenue hours". The calibration-year driving variable value will be used to establish the productivity rate that will be used, in part, in estimating future costs.

The driving variables identified for the calibration year above will also be used as input variables that will drive the estimation of costs for every item in the model. The values of these inputs will be defined by the operating plans associated with each of the alternatives analyzed, and will be used with the productivity rate discussed above in the equation that estimates O&M costs.

This same approach will be employed in identifying driving variables and values associated with each of the rail peer properties' detailed budgets.

A variable may apply to bus, rail, or both. The driving variables that will be used in the model are summarized by mode in Table 4-1, and described thereafter.

Table 4-1: Driving Variables for the O&M Cost Model

Driving Variable	Bus	Rail
Operating		
Annual Unlinked Passenger Trips	X	X
Bus Routes / Rail Lines	X	X
Vehicles Operated in Maximum Service	X	X
Maintenance Facilities	X	X
Annual Vehicle Revenue Miles	X	X
Annual Vehicle Revenue Hours	X	X
Directional Route Miles		X
Passenger Stations		X
Financial		
Capacity Miles	X	X
Salary Adjustment Factor	X	X
Fringe Rate - Bargaining, Salaried Employees	X	X
Fringe Rate - Bargaining, Hourly Employees	X	X
Fringe Rate - Non-Bargaining Employees	X	X
Alternate Year	X	X

Operating Driving Variables:

Unlinked Passenger Trips. The number of passengers who board public transportation vehicles. Passengers are counted each time they board vehicles no matter how many vehicles they use to travel from their origin to their destination. OTS served approximately 68.1 million passengers in NTD reporting year 2005.

Bus Routes / Rail Lines. The number of directly-operated scheduled fixed bus routes, or number of rail lines defined as train service, operating continuously in a unique corridor. OTS currently operates approximately 90 bus routes.

Vehicles Operated in Maximum Service. The number of revenue vehicles operated to meet the annual maximum service requirement. This is the revenue vehicle count during the peak season of the year; on the week and day that maximum service is provided. For the 2005 NTD reporting year, OTS operated 516 buses in maximum service. Vehicles operated in maximum service exclude:

- atypical days, or
- one-time special events.

Maintenance Facilities. Facilities where maintenance activities are conducted including garages, shops (e.g., body, paint, and machine) and operations centers. OTS currently operates out of four bus maintenance garages.

Vehicle Revenue-Miles. The miles that vehicles are either scheduled to travel, or actually travel, while in revenue service. For the 2005 NTD reporting year, OTS operated approximately 22.4 million vehicle-revenue miles. Vehicle revenue-miles include miles associated with:

- layover / recovery time.

Vehicle revenue-miles exclude miles associated with:

- deadheading;
- operator training; and
- vehicle maintenance testing; as well as
- school bus and charter services.

Vehicle Revenue-Hours. The hours that vehicles are either scheduled to travel, or actually travel, while in revenue service. For the 2005 NTD reporting year, OTS operated approximately 1.65 million vehicle revenue-hours. Vehicle revenue-hours include:

- layover / recovery time.

Vehicle revenue-hours exclude time associated with:

- deadheading;
- operator training; and
- vehicle maintenance testing; as well as
- school bus and charter services.

Directional Route-Miles. The mileage in each direction over which public transportation vehicles travel while in revenue service. Directional route-miles are:

- a measure of the route path over a facility or roadway, not the service carried on the facility; e.g., number of routes, vehicles, or vehicle revenue-miles; and are
- computed with regard to direction of service, but without regard to the number of traffic lanes or rail tracks existing in the right-of-way (ROW).

Directional route-miles do not include staging or storage areas at the beginning or end of a route.

The base value for this variable in determining the productivity rate will be obtained from OTS data for the bus model, and for the rail model from operating statistics of the peer rail property associated with the alternative being analyzed. The future value for this variable will be obtained for a given alternative from the specific definition of the alternative in the alternatives analysis.

Passenger stations. A passenger boarding / deboarding facility with a platform, which may include:

- stairs;
- elevators;
- escalators;
- passenger controls (e.g., faregates or turnstiles);
- canopies;
- wind shelters;
- lighting;
- signs; and
- a building with a waiting room, ticket office or machines, restrooms, or concessions. Includes all fixed guideway passenger facilities (except for on-street cable car and light rail stops), including busway passenger facilities; underground, at grade, and elevated rail stations; and ferryboat terminals. Includes transportation / transit / transfer centers, park-and-ride facilities, and transit malls with the above components, including those only utilized by motor buses.

This variable does not include stops (which are typically on-street locations at the curb or in a median, sometimes with a shelter, signs, or lighting) for:

- bus;
- light rail; or
- cable car.

The base value for this variable in determining the productivity rate will be obtained from the peer rail property operating statistics required by the associated alternative. The future value for this variable will be obtained for a given alternative from the specific definition of the alternative in the alternatives analysis.

Financial Driving Variables:

Bus Capacity-Miles. The percentage of total transit capacity-miles allocated to bus service.

Rail Capacity-Miles. The percentage of total transit capacity miles allocated to rail service.

Salary Adjustment. A variable used to adjust wages and salaries based on system size. This factor will be a fixed percentage for each additional peak bus or peak rail vehicle operated and will typically apply to staff directly involved in managing the operation.

Fringe Rate - Bargaining, Salaried Employees. The average fringe benefit rate of bargaining, salaried employees in the operations division. Fringe benefits include social security, Medicare, pension, life and medical insurance, uniform allowances, and workers compensation. Sick, holiday, vacation and other paid leave are included as base wages.

Fringe Rate - Bargaining, Hourly Employees. The average fringe benefit rate of bargaining, hourly employees in the operations division.

Fringe Rate - Non-Bargaining Employees. The average fringe benefit rate of non-bargaining employees in the operations division.

Alternate Year. A variable used to adjust 2006, model-generated O&M costs to future or past-year dollars. This will be used in the validation of the model to compare model-estimated costs to actual costs of the calibration year.

Past experience has shown that certain operating statistics generated by the travel demand forecasting model may be inaccurate due to the number of simplifying assumptions made (e.g., rounding) in developing the model, thereby resulting in overestimates of these operating statistics. As a result, annual vehicles operated in maximum service, annual vehicle revenue hours, and annual vehicle revenue miles will be calculated independently for each of the alternatives, based on the service frequency, travel time, and distance of each bus route and/or rail line. These variables will be validated by comparing estimated values for the no-build alternative with that of DTS's current operations.

Future non-revenue operations such as report, layover and deadhead time, and distance, as well as scheduled and unscheduled overtime, will be implicitly assumed to increase at current proportions. For example, if OTS's scheduled overtime hours is 2% of annual scheduled operator hours, this same ratio would be assumed for all future alternatives.

4.2.2 Determine Labor Costs

Labor costs will be determined using the following formula or a variation thereof:

Annual Labor Cost	=	*Future Driving Variable*	X	*Labor Productivity Rate*	X	*Annual Cost Per Employee*

where, *Future Driving Variable* is the input value for a given alternative of the future-year driving variable as defined by the alternatives analysis (this will be substituted with the *Base Driving Variable* (the value of the calibration-year driving variable) in initially calculating productivity rates); *Labor Productivity Rate* is the number of positions divided by the *Base Driving Variable*; and *Annual Cost Per Employee* is the average annual earnings, including salary, vacation, holiday, and sick pay, excluding fringe benefits such as medical insurance, pension, and social security.

For example, in determining the labor cost of full-time bus operators based on an alternative yielding an input variable of 750,000 revenue bus-hours per year, the model will estimate annual bus operator labor costs as follows:

The productivity rate will first be calculated by dividing the number of budgeted positions for full-time bus operators of 250 by the calibration-year annual revenue bus-hours of 550,000. The productivity rate would be .000454545 (250/550,000).

The estimated annual labor cost would then be calculated using the formula, as follows:

Annual Labor Cost	=	*Future Driving Variable*	X	*Labor Productivity Rate*	X	*Annual Cost Per Employee*
$ 11.9M	=	750,000	X	.000454545	X	$ 35,000

This example reflects an increase in annual bus operator labor costs from $8.75M (550,000 X 250) to $11.9M as a result of the increase in annual revenue bus hours from 550,000 to 750,000, thereby requiring 341 full-time bus operators ($11.9/$35,000). This is an increase of 91 operators (341-250).

Actual data will be different from the data used in this example, and will be based on OTS's budget, operating characteristics, and data yielded by the travel demand forecasting model for each of the alternatives.

Labor costs will be modeled in one of two ways, based on whether the position is an operations position or a support position. For the operations division, every position will be modeled by job classification, listing the base earnings and fringe benefit rate for each. Base earnings include sick, holiday, vacation, and other paid absences, including sick leave time reimbursement. Fringe benefit rates will account for overtime, workers compensation, social security, pension, and insurance. Positions will be distinguished as hourly vs. salaried.

For each support division, labor positions, earnings and fringe benefit rates will be aggregated by the model into a single line item.

4.2.3 Determine Non-Labor Costs

Non-labor costs will be determined using the following formula:

Annual Non-Labor Cost	=	*Total Base Cost*	÷	*Base Driving Variable*	X	*Future Driving Variable*

where, *Total Base Cost* is the actual non-labor expense for the calibration-year; *Base Driving Variable* is the value of the calibration-year driving variable that most strongly influences a cost item; and *Future Driving Variable* is the input value of the future-year driving variable for a specific alternative as defined by the alternatives analysis.

For example, the annual cost of bus parts would be estimated as follows:

The total annual base cost of bus parts will be, for the purpose of this example, $2M, and the number of peak vehicles, 50, is the base driving variable, which is the variable that most strongly influences the annual cost of parts (both of these data are obtained from the information collected from DTS). The future driving variable will be 60 vehicles, which is defined by the particular alternative. The formula would then be applied as follows:

Annual Non-Labor Cost	=	*Total Base Cost*	÷	*Base Driving Variable*	X	*Future Driving Variable*
$ 2.4M	=	$ 2M	÷	50	X	60

This example reflects that as a result of an increase in the number of peak vehicles by 10 to 60, the annual total cost of bus parts would increase by $400,000 to $2.4M.

Actual data will be different from the data used in this example, and will be based on OTS's budget, operating characteristics, and data yielded by the travel demand forecasting model for each of the alternatives.

Non-labor costs will be generally designated as services, material, energy (fuel), utilities, travel, lease, casualty, and miscellaneous, and will be aggregated by cost type for most departments, but modeled in greater detail for the operations division.

4.2.4 Build Line Item Detail Table

The line item detail table contains the model itself, which is primarily the productivity ratios and unit costs determined from detailed OTS budgetary and operating data, and from the representative peer rail properties. Outputs from the model will be the labor requirements (staffing), if any, for each category, and the estimated costs.

Labor and non-labor items will be grouped together by department, with labor items listed first. The detail will describe the category, driving variable, productivity ratio, and unit cost for each category; and the estimated staffing and costs for the service characteristics associated with the specific alternative being analyzed. An example line item detail table is shown in Table 4-2.

Rail traction power costs will be calculated according to estimated vehicle power consumption based on the service defined by the alternative, and the rates for usage and demand charged by the local power utility in Honolulu. This will be reflected in the line item detail table on a summary basis linked to a separate worksheet containing the respective detailed data and calculations.

4.3 Validating the Model

Once the model is calibrated, it will be validated by entering service characteristic data for up to two past (known) fiscal OTS years to determine if the model estimates staffing levels and costs that are nearly the same as the actual data for the past years. The service levels of the past years will ideally be somewhat different than the calibration year service levels. Any significant variations in the estimates compared to that of the actual data will be analyzed, explained, and where applicable, resolved.

4.4 Determining O&M Costs for the Alternatives

Determining O&M costs for each of the alternatives will be straightforward. The operating requirements for each alternative will be entered into the model to estimate the staffing levels and labor and material costs, as described previously.

Two O&M cost estimates will be generated for each alternative. The first will always be the cost, in 2006 dollars, to operate and maintain the existing DTS bus system at a specified level of service for the year defined by the alternative. The second will be the cost, also in 2006 dollars, to operate and maintain the particular transit system defined by the alternative. For example, that could be a light rail transit system with modified feeder bus service, or it could be a light rail transit system with modified feeder bus service in one location and standard bus route service (as with the existing System) at another location.

Table 4-2: Example O&M Cost Model Line Item Detail Table[6]

1 acct	2 resource category	3 driving variable	4 productivity ratio	5 unit cost	6 staff	7 cost (000)
010	office of director of operations	peak veh	1 staff per 200 peak veh	$47,000 per staffer		
	schedulers	peak veh	1 staff per 65 peak veh	$28,700 per staffer		
	shift supervisor	garage	3 supervisors per garage	$38,400 per supervisor		
	street supervisor	veh-hr	1 supervisor per .14MM veh-hr	$34,100 per supervisor		
	support staff	garage	5 staff per garage	$22,000 per staffer		
032	fuel	veh-mi	.31 gal per veh-mil	$.94 per gal	NA	
	lubrication	veh-mi	--	$.012 per veh-mi	NA	

[6] *Procedures and Technical Methods For Transit Project Planning, Part II, Chapter 4, Operating and Maintenance Costs.* Washington, D.C.: Federal Transit Administration, 1990.

1	2	3	4	5	6	7
acct	**resource category**	**driving variable**	**productivity ratio**	**unit cost**	**staff**	**cost (000)**
033	tires and tubes	veh-mi	--	$.021 per veh-mi	NA	
042	office of director of maintenance	peak veh	1 staff per 250 peak veh	$38,000 per staffer		
	maintenance supervisors	garage	3 supervisors per garage	$36,200 per supervisor		
	support staff	garage	2 staff per garage	$22,000 per staffer		

4.5 Presenting the Data

The output data of the model will be presented in the Memorandum on O&M Cost Estimating Results, with summary tables describing each of the alternatives, the values of their input variables, and the values of the outputs for staffing requirements and costs. Additional summary tables organizing this information according to department and cost type (e.g., labor, services, utilities, etc.) will also be provided. Detailed tables incorporating all data for each of the alternatives will also be developed for use as required.

5 Conclusion

The alternatives analysis study is intended to provide information to local officials on the benefits, costs, and impacts of alternative transportation investments developed to address the purpose and need for a transportation improvement in the corridor. The ultimate outcome of the study is the selection of a locally preferred alternative from the list of defined alternatives.

In support of this, each of the alternatives will be evaluated according to a set of criteria collectively referred to as project justification and local financial commitment criteria, which generally include 1) mobility improvements; 2) cost-effectiveness; 3) environmental benefits; 4) operating efficiencies; 5) transit supportive land use; 6) local financial commitment; and 7) other factors such as environment justice considerations and equity issues; opportunities for increased access to employment for low income persons and welfare to work initiatives; livable communities initiatives and local economic development initiatives; and consideration of innovative financing, procurement, and construction techniques, including design-build turnkey applications.

O&M cost estimates for each of the alternatives will be an important part of the cost effectiveness and local financial commitment criteria used in the evaluation of alternatives leading to the selection of the locally preferred alternative. The O&M cost estimates will also comprise part of the project justification criteria submitted to the FTA for its review and ultimate rating of the project.

References

Department of Transportation Services. August 2003. City and County of Honolulu. 13 October 2005 <http://www.co.honolulu.hi.us/budget/cityorganization/dts.htm>.

Estimation of Operating and Maintenance Costs for Transit Systems. Washington, D.C.: Technology Sharing Program, U.S. Department of Transportation, 1992.

Procedures and Technical Methods For Transit Project Planning, Part II, Chapter 4, Operating and Maintenance Costs. Washington, D.C.: Federal Transit Administration, 1990.

Procedures and Technical Methods For Transit Project Planning, Part II, Chapter 8, Financial Planning for Transit. Washington, D.C.: Federal Transit Administration, 2003.

DTS 2005 NTD - Agency Profile Data

	Bus (TheBus)	Demand Response (TheHandi-Van)	Total
Vehicles Operated in Maximum Service	416	100	516
Vehicle Peak to Base Ratio	1.56	NA	NA
Average Fleet Age in Years	7.3	4.7	NA
Annual Vehicle Revenue Miles	18,388,911	4,035,830	22,424,741
Annual Vehicle Revenue Hours	1,365,082	283,396	1,648,478
Annual Unlinked Trips	67,406,827	733,777	68,140,604
Annual Passenger Miles	291,109,916	8,966,697	300,076,613
Service Efficiency			
Operating Expense per Vehicle Revenue Mile	$ 6.91	$ 4.25	NA
Operating Expense per Vehicle Revenue Hour	$ 93.08	$ 60.58	NA
Cost Effectiveness			
Operating Expense per Passenger Mile	$ 0.44	$ 1.91	NA
Operating Expense per Unlinked Passenger Trip	$ 1.89	$ 23.40	NA
Service Effectiveness			
Unlinked Passenger Trips per Vehicle Revenue Mile	3.67	0.18	NA
Unlinked Passenger Trips per Vehicle Revenue Hour	49.38	2.59	NA

DTS 2005 NTD - Operating Expenses by Function (in 000's)

	Bus (TheBus)	Demand Response (TheHandi-Van)	Total
Vehicle Operations	$ 79,491	$ 11,932	$ 91,423
Vehicle Maintenance	$ 26,309	$ 1,977	$ 28,286
Non-Vehicle Maintenance	$ 3,262	$ 297	$ 3,559
General Administration	$ 18,007	$ 2,963	$ 20,970
Total	$ 127,069	$ 17,169	$ 144,238

DTS 2005 NTD - Operating Expenses by Object Class (in 000's)

	Bus (TheBus)	Demand Response (TheHandi-Van)	Total
Operators' Wages	$ 36,550	$ 6,371	$ 42,921
Other Salaries and Wages	$ 21,517	$ 2,534	$ 24,051
Fringe Benefits	$ 37,211	$ 4,305	$ 41,516
Services	$ 2,973	$ 547	$ 3,520
Material and Supplies - Fuel and Lube	$ 9,398	$ 1,056	$ 10,454
Material and Supplies - Tires and Other	$ 8,099	$ 852	$ 8,951
Utilities	$ 1,198	$ 66	$ 1,264
Casualty and Liability	$ 7,638	$ 1,108	$ 8,746
Taxes	$ 2,283	$ 231	$ 2,514
Purchased Transportation	$ 0	$ 0	$ 0
Other	$ 202	$ 100	$ 302
Total	$ 127,069	$ 17,169	$ 144,283

DTS 2005 NTD - Operators' Wages

	Bus (TheBus)
<u>Operating Time - Dollars (in 000's)</u>	
Platform Time	$ 30,941
Straight Time Allowances	$ 1,949
Premium Time	$ 2,798
Non-Operating Paid Work Time	$ 862
Total Amount	$ 36,550
<u>Operating Time - Hours (in 000's)</u>	
Platform Time	1,509
Straight Time Allowances	97
Premium Time	273
Non-Operating Paid Work Time	62
Total Hours	1,941

DTS 2005 NTD - Energy Consumption (in 000's)

	Bus (TheBus)	Demand Response (TheHandi-Van)	Total
Gallons of Diesel Fuel	6,383	641	7,025

DTS 2005 NTD - Employee Work Hours and Counts

	Bus (TheBus)	Demand Response (TheHandi-Van)	Total
Employee Work Hours			
Vehicle Operations	2,106,803	422,989	2,529,792
Vehicle Maintenance	516,671	43,426	560,097
Non-Vehicle Maintenance	65,831	7,185	73,016
General Administration	196,096	39,715	235,811
Total Operating	2,885,401	513,315	3,398,716
Actual Employee Count			
Vehicle Operations	1,013	224	1,237
Vehicle Maintenance	301	27	328
Non-Vehicle Maintenance	36	6	42
General Administration	111	22	133
Total Operating	1,461	279	1,740

DTS 2005 NTD - Service Supplied and Consumed

	Bus (TheBus)	Demand Response (TheHandi-Van)	Total
Vehicles Available for Maximum Service	525	123	648
Service Supplied (in 000's)			
Annual Scheduled Vehicle Revenue Miles	18,474	0	18,474
Annual Vehicle Miles	21,558	5,014	26,572
Annual Vehicle Revenue Miles	18,389	4,036	22,425
Annual Vehicle Hours	1,493	354	1,847
Annual Vehicle Revenue Hours	1,365	283	1,648
Service Consumed (in 000's)			
Unlinked Passenger Trips	67,407	734	68,141
Passenger Miles	291,110	8,967	300,077

DTS 2005 NTD - Maintenance Facilities

	Bus (TheBus)	Demand Response (TheHandi-Van)	Total
General Purpose - Under 200 Vehicles	0	1	1
General Purpose - 200 to 300 Vehicles	2	0	2
Heavy Maintenance	1	0	1
Total	3	1	4

DTS 2005 NTD - Transit Way Mileage

	Bus (TheBus)
Lane Miles	
Exclusive Right-of-Way	1
Controlled Right-of-Way	35
Directional Route Miles	
Exclusive Right-of-Way	1
Controlled Right-of-Way	35
Mixed Traffic	883

DTS 2005 NTD - Age Distribution of Active Vehicle Inventory

	Articulated Bus (60 ft.)	Bus (40 ft.)	Vans (20-35 ft.)
Years			
5 or less	60	120	88
6 to 11	0	213	51
12 to 15	0	67	12
16 to 20	0	0	0
Summary			
Total Active Fleet	60	400	151
Average Age of Fleet (in Years)	3.2	7.9	5.4

Honolulu High-Capacity Transit Corridor Project

Travel Forecasting Methodology Report

June 30, 2006

Prepared for:
City and County of Honolulu

Prepared by:
Parsons Brinckerhoff Quade & Douglas, Inc.

TABLE OF CONTENTS

1.0 Introduction

The City and County of Honolulu (City), in cooperation with the Federal Transit Administration (FTA), is initiating an Alternatives Analysis (AA), leading to preparation of a Draft Environmental Impact Statement (DEIS), to identify and evaluate high capacity transit service improvements along a corridor between Kapolei and the University of Hawaiʻi at Mānoa (UH Mānoa). This report describes the travel forecasting methods, assumptions, and supporting analytical procedures that will be applied in the analysis and evaluation of transit alternatives under consideration.

The methodology report is an evolving document in which this first installment provides discussion of the intended technical approach to the travel forecasting effort. Specifically, it describes proposed modifications to the Oʻahu Metropolitan Planning Organization's (OMPO) current travel demand model for use in producing baseline and future year forecasts for various transit alternatives for the Honolulu High-Capacity Transit Project. Consequently, the material contained in the deliverables should be considered as work in progress. It is subject to revision as comments are received and responded to by project staff; it may be superseded as a result of subsequent activities.

2.0 Model Overview

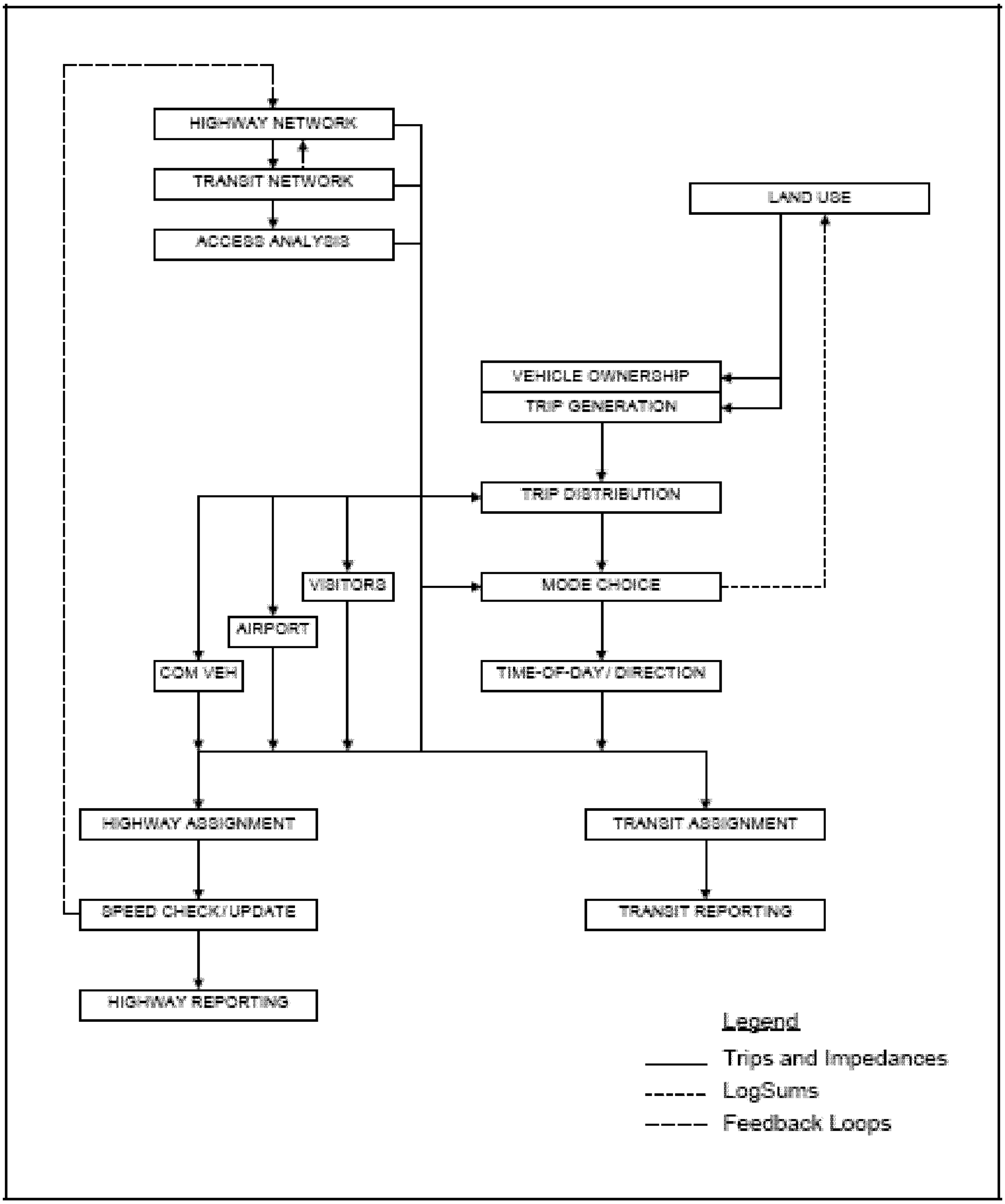
The Oʻahu Metropolitan Planning Organization's (OMPO) "best-practice" models have adopted the general structure that has been used for several decades for urban travel models in the United States. All model sets that have been developed recently in several urban areas have continued to use this "sequential" approach to travel forecasting in which travel patterns are assumed to be the product of a sequence of individual decisions:

- the number of trips that a household will make – "trip generation;"
- the destinations of these trips – "trip distribution;"
- the modes that will be used for travel – "mode choice;" and
- the paths on the network that the trips will take – "network assignment."

The various travel models used by OMPO are described in the *Guide to Model Form*, included within the *Final Documentation* for the Travel Forecasting Model Development Project of the Oʻahu Metropolitan Planning Organization, December 17, 2002. The *Guide to Model Form* is attached as an Appendix to this Methodology Report.

Figure 1 below shows the sequence of model procedures in flow chart form of the current OMPO models.

FIGURE 1



AR00076874

3.0 Model Refinement

For the purpose of the Honolulu High-Capacity Transit Corridor Project the current OMPO model is being refined and augmented to better represent transit alternatives in the corridor. The refinements are occurring in three parts. First, the existing models are being reviewed, enhanced, recalibrated and validated, using existing calibration datasets, consistent with current FTA guidelines. Second and concurrently, a new on-board transit survey is being completed. Third, the model choice model will be recalibrated and validated using data from the new on-board survey.

Changes to Existing OMPO Model

The following activities are being undertaken as part of the review, enhancement and recalibration of the existing models.

1. Implementation and Testing of a Toll Choice Component for the Mode Choice Model,
2. 1992 On-Board Survey Assignment Analysis,
3. Tests of Alternative Highway Volume–Delay Functions,
4. Examination of Variations in Speed Table/Free Flow Speed Assumptions,
5. Review of Transit Travel Time Functions,
6. Year 2000 CTTP Person Trip Matrix Comparisons,
7. Evaluation of Parking Cost Representation and Forecasting,
8. Preparation of Revised Calibration Target Values,
9. Re-Calibrate Mode Choice Model and Make Model Structural Changes,
10. Prepare Transit and Highway Validation Comparisons and Model Adjustments (as needed), and,
11. Prepare Model Re-Calibration and Validation Report.

Reports describing work completed to date on tasks 1 through 9 are included in Appendix B.

New On-Board Survey and Model Re-Calibration

A new on-board survey is underway as part of this project to re-calibrate the model prior to developing final forecasts. The on-board survey will provide mode choice calibration target values for each of the transit modes. Also, the observed transit trip tables by time period, mode, and mode of access will be assigned to the transit networks. Comparisons of estimated versus reported boardings by period, mode, and mode of access will be used to validate transit networks. Moreover, this model enhancement effort will also attempt to implement a route level capacity restraint capability.

4.0 Alternatives Analysis

The travel forecasting element of the AA will used to evaluate a relative comparison of the "build" alternatives to the "baseline" or TSM alternative. Number of transit boardings, highway and transit travel times, vehicle hours traveled, vehicle hours of delay, vehicle miles traveled, and FTA's SUMMIT software results are some of the forecasts that help in the selection of a Locally Preferred Alternative at the conclusion of the study.

Moreover, these travel forecasts incorporate the Section 5309 New Starts Project Justification Criteria. These include:

- Cost Effectiveness
    i. Incremental cost per hour of transportation system user benefit
    ii. Increment cost per new rider
- Transit Supportive Land Use and Future Patterns
    i. Existing land use
    ii. Transit supportive plans and policies
    iii. Performance and impact of policies
- Mobility Improvements
    i. Normalized travel time savings (transportation system user benefits per project passenger mile)
    ii. Low income households served
    iii. Employment near stations
- Operating Efficiencies
    i. System operating cost per passenger mile
- Environmental Benefits
    i. Change in regional pollutant emissions
    ii. Change in regional energy consumption
    iii. EPA air quality designation

Key Input Assumptions

The development of ridership forecasts requires the estimation of a large amount of supporting information that is of potential interest to a variety of audiences: changes in population and employment in various subareas, increasing congestion levels, travel time savings available from new transit guideways, transit's share of various transit markets, and so forth. Reviews of this information can be crucial in isolating problems in initial forecasts and increasing the credibility of the final results. Consequently, efforts to prepare the travel forecasts for the Honolulu High-Capacity Transit Corridor Project AA will emphasize the development of documentation and presentation materials that highlight the key underlying characteristics of travel in the region.

The ridership forecasts will be based on a single set of projections and policies consistent with the 2030 O'ahu Regional Transportation Plan (ORTP) and will be held constant for the preparation of travel forecasts for the baseline and build alternatives, including:

- Land use, demographics, socio-economic characteristics (See Appendix C for data by Traffic Analysis Zone (TAZ)), and travel patterns;
- The highway network, except as modified for changes inherent to the build alternative (such as the conversion of traffic lanes to transit-only rights-of way) will be held constant between the baseline (TSM) and build alternatives.
- Transit service policies regarding geographic coverage, span of service, and headways, modified where necessary to integrate transit guideways into the bus system;
- pricing policies (fares ($0.42), highway tolls, and parking costs(differs by zone, varies between ($0 and $3.05));
- transit capacity provided given project transit volumes, productivity standards, and load standards.

Forecast Evaluation Techniques

FTA's SUMMIT software tool for analyzing travel forecasts results will be used to calculate the transportation system user benefit calculations. A series of reports and maps produced by the results of the Summit software provides an insight into the reasonability of the ridership forecasts and the transportation user benefit calculations.

For example, the row and column sum report files (".rcu" and ".rcs" file extensions) provide by TAZ, the difference in person trips between alternatives, the difference in total transit trips, and the total user benefits. These files can be used to produce thematic maps to show by each trip purpose, the benefits of trips produced in the zones (row sums), and the benefits of trips attracted to the zones (column sums), where several shades of green would be positive benefits, and several shades of red would signify negative benefits. And this map would show the project alignment and station locations so we would expect positive benefits to be shown alongside the transit alignment.

Several key indicator statistics that are provided to FTA in the User Benefits Quality Control (UBQC) Worksheet are:

- Total Transit Trips for TSM Alternative
- Total Transit Trips for BUILD Alternative
- Total Person Trips for BUILD Alternative
- User Benefits in Hours (Daily)
- "Off-Diagonal" User Benefits in Hours
- Total Change in User Benefits from capped prices

Appendix A: Guide to Model Form

TRAVEL FORECASTING MODEL DEVELOPMENT PROJECT OF THE OAHU METROPOLITAN PLANNING ORGANIZATION

HONOLULU, HAWAII

FINAL DOCUMENTATION

DECEMBER 17, 2002

PARSONS BRINCKERHOFF QUADE & DOUGLAS, INC.

IN ASSOCIATION WITH:

APPLIED MANAGEMENT AND PLANNING GROUP
GEORGE HOYT & ASSOCIATES
KAKU ASSOCIATES
MATTSON-SUNDERLAND RESEARCH
MIDWEST SYSTEMS SCIENCES
URBAN ANALYTICS

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Attachments (on compact discs)

A. Model Application Software and Set-ups

B. Data Library

C. Final Documentation

D. Application Software Fortran Source Code

Guide to Model Form – Travel Models

A. Introduction

The status of travel forecasting procedures for Oahu parallels the situation found in most urban areas in the United States. These procedures were developed more than two decades ago, with limited data, and with a basic structure typical of models from the 1970s and early 1980s. As in other urban areas, the Oahu models have become dated because of at least three trends:

1. Significant changes have occurred in the area for which the models are supposed to describe land-use and travel patterns. Oahu has evolved rapidly in terms of population and employment, transportation facilities, land-use policies, socio-economic characteristics, housing costs, and the travel patterns that result from this broad range of influences.
2. The requirements placed on the forecasting procedures have grown. Where travel forecasting once focused on predicting the necessary capacity for new highway and facilities, they are now asked to deal with a much broader set of issues introduced by, among other requirements, the Surface Transportation Efficiency Act and the Clean Air Act Amendments. High-occupancy-vehicle lanes, land-use controls and incentives, site-impact analyses, transportation demand management (TDM) strategies, and transportation system management (TSM) programs are primary examples.
3. Methods for travel forecasting have advanced substantially over the past 10-15 years. Where the typical model set developed in the early 1980s consists of a series of more-or-less independent models that share information only very loosely, newer methods do a much better job of using information on the transportation system and the travelers on the system. Many of the technical improvements that have been made in the procedures are crucial in the useful analysis of the new, broader set of issues faced by transportation agencies.

In light of these significant trends, it is not surprising that OMPO is one of a large number of regional planning agencies in the United States that have updated their travel forecasting procedures.

Specific OMPO Requirements and Resulting Features

The new forecasting procedures must be able to address a set of specific requirements that has been identified by OMPO with the help of the Forecasting Task Force and the Peer Review Group. These requirements specify that the forecasting procedures must support OMPO and its member agencies to examine changes in travel patterns and/or land use development in support of a variety of planning analyses:

- project-level forecasting for highway improvements for both general traffic and high-occupancy vehicles;
- analysis of alternative land-use policies and their implications for travel patterns and transportation improvements;
- analysis of traffic impacts in subareas around significant new developments;
- analysis of strategies to manage transportation demand to relieve congestion and preserve air quality;
- consideration of major fixed-guideway transit investments, including access to stations, competition with bus routes, and sensitivity to different fare policies; and

- planning for strategic bus improvements, including broad service enhancements and fare-policy changes.

In view of these requirements, the most important specification for the new models is that they capture as realistically as possible the travel behavior of residents of Oahu. Any additional feature designed to answer a specific requirement is of limited utility if the underlying models ignore or misunderstand the decisions that households make and the influences on these decisions.

Model Development Overview

The OMPO "best-practice" models have adopted the general structure that has been used for several decades for urban travel models in the United States. All model sets that have been developed recently in several urban areas have continued to use this "sequential" approach to travel forecasting in which travel patterns are assumed to be the product of a sequence of individual decisions:

- the number of trips that a household will make -- "trip generation;"
- the destinations of these trips -- "trip distribution;"
- the modes that will be used for travel -- "mode choice;" and
- the paths on the network that the trips will take -- "network assignment."

Because the sequence includes four basic decisions, the general approach has often been termed the "4-step process."

Since the mid-1990's , a rising chorus of criticism has highlighted what has been known for some time: typical applications of the sequential approach to travel forecasting have many undesirable features. Three general themes stand out in these critiques:

1. the sequential models do not use information consistently throughout;
2. important influences on travel patterns are entirely absent from the models; and
3. important choices are ignored, or a represented very crudely.

All of these criticisms are legitimate when they are applied to the "typical" implementation of the sequential model set. However, they are not necessarily fatal flaws; rather, they serve to highlight the components of the sequential model set that must be done better.

In practice, recently developed model sets have, in fact, made significant strides in overcoming many of these limitations. While no single urban area currently has models that include all of these improvements, all of these improvements can be found in one or more of the recently developed model sets in the United States. Together, these new model sets demonstrate the full range of refinements that are being made to the sequential approach to travel forecasting. Consequently, the development of the OMPO "best-practice" procedures adopt these approaches, and add several additional improvements to overcome most of the limitations found in older sequential model sets.

Organization of This Report

The remaining sections of this document describe the formulation, estimation, calibration, and validation, and application of the new OMPO forecasting procedures. The report is subdivided into two major sections – Guide to Model Form and User's Guide to Model Application. Development of the UrbanSim Land Use Model is contained in a separate volume. There are also a series of appendices to the report which detail the data library for the model system.

B. Transportation System Models

1. Overview

This part of the documentation describes the process for organizing information relevant to the transportation planning networks for the Oahu Metropolitan Planning Organization (OMPO.) This information includes spatially referenced descriptions of the highway infrastructure, highway and transit service levels, underlying land use and socioeconomic characteristics on the island of Oahu, and a framework for relating highway facility utilization and transit patronage information resulting from the travel forecasting process. The organization of such transportation network information requires procedures for integrating such information into consistent representations of alternative network data files as required by transportation planning application software. The following sections, therefore, describe the important elements of transportation networks for travel demand modeling, the organization of data, and the methodology for generating required data formats for the transportation planning application software.

The highway network in travel demand modeling is an abstraction of real or proposed facilities for serving the general driving public, commercial vehicles providing public transportation and goods movement services, bicyclists, and pedestrians. The abstraction emphasizes connectivity and spatial separation of the activity centers from which demand for travel emerges rather than representing physical details such as curvature, grade, and surface type, although these features are accounted for implicitly in the representation of vehicle throughput (capacity) for the roadway.

The transit network represents the spatial and temporal connectivity of the public transportation system on Oahu by relating transit routes and service levels to the highway network and thus to travel activity centers. The transit network abstraction allows generalized measures of separation to be determined between areas of the island which reflects weighted average in-vehicle travel time, access/egress time, out-of-vehicle waiting and transfer times, and cost.

In a typical travel forecasting modeling methodology, travel demand is represented as groups of travelers of similar travel characteristics assigned to spatial units called traffic analysis zones (TAZs). Opportunities for satisfying activities (employment, shopping, recreation, etc.) are represented for each TAZ as well. The transportation networks provide a means for measuring the spatial separation between the groups of travelers and the opportunities they are attempting to realize. This separation, or as often called impedance measure, affects the decisions travelers make in their destination, departure time, mode and route choices. The transportation networks are thus used to determine the demand for travel on routes between centers of activities. This demand for travel on routes of the networks may ultimately be related back to the transportation facilities being represented in the model to evaluate the transportation impacts of land use, facility, and service level changes, among other transportation policy concerns.

The following sections identify transportation network-related information that must be collected, assembled, and evaluated in order to perform travel demand forecasting. This information will be described in terms of its use in the modeling process and potential data collection issues. The data items specified will be necessary both directly and indirectly to formulate the actual network used by the application software. Thus, methods for organizing the data for pre-processing, model application, and post-processing analyses will be presented.

2. Highway

2.1 Highway Network Elements

The fundamental elements of a transportation planning highway network are nodes and links. The network is constructed by connecting links together by nodes. Links are uniquely defined by the nodes at each end. The network links relate to roadway segments between intersections or points of juncture, which are represented by the nodes.

In transportation planning application software, nodes are used merely as indices to links. The indices are used in referencing the links during a shortest path building procedure and for spatially referencing the links during the graphical mapping of the network to a display device.

Links have associated with them the majority of network information, often called attributes. Link attributes describe such things as type of facility, speed, capacity, etc. for the road segment being represented by the link. Links connected at nodes allow a representation of the highway supply relationships to be made for which highway travel demand may be realized.

Traffic Analysis Zones (TAZs) represent the geographic stratification of a metropolitan study area into areas likely to produce travelers of similar characteristics and attract travelers of similar characteristics within the constraints of application software and the ability of the local planning authorities to collect and maintain realistic data. The TAZs are the units for which aggregate travel demand is estimated. This demand is then allocated to highway routes based on some behavioral hypothesis regarding the decisions made by travelers in choosing routes; for example, user-optimal equilibrium route choice is founded on the premise that at equilibrium, no traveler can lower his impedance of travel by switching to a different route.

To allocate this demand to the highway routes, a mechanism is needed to relate the zone to zone travel demand to the highway network. This mechanism is the use of network links called centroid connectors. The centroid is a node representing the point of entry to a network for travelers leaving a zone and the exit point for travelers arriving at a zone. During the traffic assignment procedure of the typical urban transportation modeling process, the travel demand for each pair of zones is assigned to routes between the zones represented by network paths connecting the pairs of centroid links.

Turn restrictions complete the information needed to develop the highway network. Turn restrictions specify link pairs that represent turns or illegal movements. The link pairs are subsequently ignored by the shortest path building routines in the application software so that the illegal movements are never considered during route choice or when computing network derived interzonal travel measures.

2.2 Node-Related Data

In a transportation network, nodes represent intersections and intermodal transfer points; in other words, locations where decisions in route choices are made by travelers. In travel forecasting methodologies, network models are link oriented. Information gathered or computed for nodes is done so in order to relate to the links connecting pairs of nodes. The following information is gathered for nodes in the highway network:

Node Labels are used to uniquely name the nodes, usually by numeric labels, so that links may likewise be uniquely named by the pair of node labels at each end of the link. Internally, the transportation planning software references links by the node numbers (often referred to as a-node and b-node, or from-node and to-node) when building shortest paths, assigning origin/destination flows to paths, etc.

Numeric centroid labels are most often restricted to be in the range of one to the largest zone number with a one to one correspondence between zone number and centroid number. Most application software requires that zone numbers (i.e. centroid numbers) be numbered sequentially.

In addition to numeric labels required by the application software, alphanumeric labels are often maintained in the highway network database to allow analysts to easily recognize node locations. An example might be a label describing the intersecting streets at the intersection represented by a node. This information is descriptive and is primarily intended for report generation and database queries; it is not used by the transportation planning application software.

Geographic Coordinates are used to spatially reference the nodes. Spatial referencing of links, determined by the spatially referenced nodes, is important for relating zonal information such as employment or population density to links. This relationship is typically done by averaging zonal densities for all zones with centroids within a certain distance of the nodes at each end of a link. The density determined for the link is therefore representative of the socioeconomic climate of the area surrounding the link.

Node coordinates also provide application software with the information necessary to display networks and network attributes on an output device such as a computer terminal, plotter or printer. Visual representation of networks and network related information is one of the most important features that application software gives the transportation planning analysts.

2.3 Link-Related Data

The link attributes described in this section constitute the information necessary to make detailed, link-specific capacity and travel delay calculations, as well as support state-of-the-practice travel demand modeling. The attributes described are:

- Link Identifiers (including street names)
- Facility Type
- Area Type
- Distance
- Speed
- Vehicle/Mode Restrictions
- Number of Lanes
- Capacity

Link Identifiers are the numeric node labels at each end of the link. The order of the nodes when describing a link determines direction. For example, a link identified as (a-node, b-node) indicates one direction while (b-node, a-node) indicates the opposite direction.

Facility Type of a link is defined as a function of the geometric and operational characteristics of the road. These characteristics include the intersection designs, control characteristics, number of lanes etc. Facility type is used to stratify the network links for the purpose of computing summary statistics to determine the quality of the model results. Facility type is also used as an index variable to a table of free flow speed and capacity for links. Facility types and descriptions of roadway features they characterize follows:

Freeways (facility code 1)are limited-access roadways with fully grade-separated interchanges and no at-grade access or signals. At least two lanes in each direction. Directional travel lanes are always separated by a median or concrete barrier. Shoulders exist for disabled vehicles to move out of the traffic stream. No parking is allowed within the freeway right-of-way.

Expressways (facility code 2)are high-speed, controlled-access roadways. Major cross roads (Class I arterial and above) are usually grade-separated, other cross roads are either right turn in or right turn out, or controlled by signals, with the expressway having at least 80% of the green time. At-grade intersections always have left turn lanes or prohibit left turns. No driveway access, but frontage roads may exist. Usually two to four lanes in each direction. Directional movements are separated by a median or concrete barriers.

Class I Arterials (facility code 3) are major arterials. Higher type cross roads are usually grade separated. Lower type cross roads are controlled by signals, with the Class I arterial having approximately 70% of the green time (or semi-actuated controls favoring the arterial). Class I arterials are usually part of progressive signal and/or computer controlled signal systems with progression favoring the Class I arterial. Signal spacing is wide, averaging no more than 2 signals per mile. At-grade intersections usually have left turn lanes and often have right turn lanes. Frontage roads are common and driveway access is infrequent. Directional movements are usually separated by a median or concrete barrier. Parking is usually not allowed.

Class II Arterials (facility code 4) are medium arterials. Higher type cross roads are grade separated or controlled by signals, with the Class II arterial having no more than 30% of the green time. Lower type cross roads are controlled by signals, with the Class II Arterial having at least 60% of the green time (or semi-actuated controls favoring the Class II Arterial). The Class II arterial may have progressive signals and/or computer controlled signal systems with the progression favoring the Class II Arterial. On average, there are no more than six signals per mile. At-grade intersections always have left-turn lanes and sometimes have right turn lanes. Typically, one to three lanes in each direction are found. Some driveways, but no frontage roads are common. Directional movements are usually separated by painted or raised median or concrete barrier. Parking is usually not allowed.

Class III Arterials (facility code 5) are minor arterials. Higher type cross roads are grade separated or controlled by signals, with the Class III Arterial having no more than 40% of the green time. Lower type cross roads are controlled by signals, with the Class III Arterials having at least 60% of the green time. No progressive signals or computer controlled signal systems are usually found. On average, there are no more than 10 signals per mile. At-grade intersections usually have left turn lanes but rarely have right turn lanes. One or two lanes in each direction are common. Driveway access is common, but no frontage roads. Directional movements are usually separated by painted median. Parking may be allowed in off-peak hours, though is often restricted to boost capacity during peak travel times.

Class I Collectors (facility code 6) are major collectors. Higher type cross roads are grade separated or controlled by signals, with the Class I Collector having no more than 40% of the green time. Lower type cross roads are controlled by stop signs or signals, with the Class I Collector having at least 60% of the green time. There are usually no progressive signals or computer controlled signal systems. On average, no more than 12 signals per mile are found. At-grade intersections may have left-turn lanes, but no right turn lanes. Usually 1, but sometimes 2 lanes in each direction. Many have driveways, but no frontage roads. Directional movements are separated by painted median. Parking may be allowed during off-peak hours and may be restricted during peak hours.

Class II Collectors (facility code 7) are minor collectors. Higher type cross roads are grade separated or controlled by signals, with the Class II Collector having no more than 40% of the green time. Lower type cross roads are controlled by stop signs or signals, with the Class II Collector having at least 60% of the green time. No progressive signals or computer controlled signal systems. Many signals per mile is typical. At-grade intersections do not have left-turn lanes, but no right turn lanes. Usually 2 lanes (both directions). Class II collectors have more driveways than Class I Collector, and also are without frontage roads. Directional movements may not be separated by median. Parking is typically always allowed.

High-Speed Ramps (facility code 9)include "outer" ramps for cloverleaf interchanges, "slip" ramps, ramps for directional interchanges, and other ramps with large radius of curvature (500 ft or more). No signals or stop signs at the end of the ramps. Ramp metering signals located prior to acceleration area may be present. Merge areas are of adequate length. No driveways, frontage roads, parking are permitted. One or two lanes exist in one direction.

Low-Speed Ramps (facility code 10) include "inner" ramps for cloverleaf interchanges and other ramps with short radius of curvature. End of the ramp may be controlled by stop sign or signal. Merge area is barely long enough for safe traffic operation. There is always 1 lane in one direction. No driveways, frontage roads, or parking are permitted.

Centroid Connectors (facility code 12) are surrogates for all the local streets used to access the highway network. Assigned two lanes in each direction with very large capacity values so as to preclude capacity restraint. Connectors for a zone are coded with a representative distance given knowledge of the local streets for which access to the higher type roadways is provided. Centroid connectors are a construct required for the traffic models and have no direct interpretation other than abstraction of omitted roadways.

Area Type usually defines the socioeconomic characteristics of the immediate area in which the link is located. Area type is defined in terms of the population and employment densities of the zones closest to the link. The densities are computed as the sums of the employment and (separately) population in zones in the area of the link, divided by the sum of the land area of the same zones. Through experimentation, we have selected for Oahu a (centroid-to centroid) radius of one-half mile to identify the zones in the area of the link.

The floating population and employment densities of a zone combine to define its area-type. We have defined eight discrete area types. The overall density defines whether the area is Central Business District (CBD), Core, Urban, Suburban or Rural. Within these we define Commercial or Residential subtypes based on the zone's relative density of employment and population. The eight categories are labeled: 1) CBD, 2) Core Commercial, 3) Core Residential, 4) Urban Commercial, 5) Urban Residential, 6) Suburban Commercial, 7) Suburban Residential and 8) Rural. The employment and population density categories corresponding to each area-type are shown below.

Area-Type Definitions Based on Population and Employment Densities

Employment Category (Employees per Square Mile)	≤12	≤93	≤397	≤1,615	≤6,202	≤22,630	≤78,500	>78,500
Population Category (Population per Square Mile)								
0	8	8	7	6	4	4	2	1
≤192	8	8	6	6	4	4	2	1
≤1,623	7	7	7	6	4	4	2	1
≤4,975	7	7	7	7	4	4	2	1
≤11,588	5	5	5	5	5	4	2	1
≤24,000	5	5	5	5	5	5	2	1
≤42,866	3	3	3	3	3	3	3	1
>42,866	3	3	3	3	3	3	3	1

Link Distance measures the actual separation of nodes. Since transportation modeling highway networks are abstractions of "real world" roadway networks, a link, determined by the two nodes representing intersections at each end, could represent a roadway intersected by many local streets not included in the planning network. This roadway could have any geometric alignment, and thus the roadway distance could be quite different from the "straight-line distance" determined by measuring between the end intersections (or calculated from the node coordinates). An accurate "over-the-road" distance is thus important information for each link representing a roadway in the network.

Link Speed is measured and computed under various conditions. Free flow speed is the average speed of vehicles on a link under non-congested operating conditions. Congested speed is the average speed of vehicles operating under constrained conditions due to traffic volumes which cause travelers to consider alternative routing, and/or are at levels which result in slowed conditions. The congested speed table which follows simply represents a starting point for the computation of interchange level congested travel times. After successive iterations of feedback, a unique set of link level congested speeds are estimated.

Free Flow Speed Table

Free flow speed is an operand of volume/impedance functions and thus is an important item of input data. The following table shows observed free flow speeds, categorized by facility type and area type.

Area Type	CBD	Core Commercial	Core Residential	Urban Commercial	Urban Residential	Suburban Commercial	Suburban Residential	Rural
Facility Type								
Freeway	60	63	63	65	65	68	68	68
Expressway	54	57	58	59	60	60	63	63
Class I Arterial	34	35	35	37	37	41	45	47
Class II Arterial	30	32	32	34	35	40	42	47
Class III Arterial	28	30	30	32	33	37	40	47
Class I Collector	26	28	28	30	30	35	39	46
Class II Collector	24	26	27	28	28	33	38	45
Local Street	12	17	18	19	20	25	30	32
High Speed Ramp	50	50	51	51	52	52	55	57
Low Speed Ramp	25	30	30	30	30	35	35	37
Centroid Connector	12	17	18	19	20	25	30	32

Congested Speed Table

To begin the travel demand process, an estimate of congested times is required. The following table shows observed congested speeds, categorized by facility type and area type.

Area Type	CBD	Core Commercial	Core Residential	Urban Commercial	Urban Residential	Suburban Commercial	Suburban Residential	Rural
Facility Type								
Freeway	24	30	30	45	45	68	68	68
Expressway	22	24	24	30	30	37	37	42
Class I Arterial	19	22	22	25	25	37	37	42
Class II Arterial	16	17	17	20	20	28	28	40
Class III Arterial	14	16	16	18	18	24	24	37
Class I Collector	12	15	15	17	17	21	21	35
Class II Collector	9	12	12	15	15	21	21	31
Local Street	9	12	12	15	15	20	20	25
High Speed Ramp	12	15	15	18	18	24	24	34
Low Speed Ramp	6	9	9	12	12	18	18	28
Centroid Connector	9	12	12	15	15	20	20	25

Vehicle/Mode Restrictions refer to information about what modes and vehicle types are allowed to operate on links. Pedestrian and bicycle paths do not allow motorized traffic, except that mopeds may be allowed on bicycle paths. Likewise, freeways usually do not allow pedestrians, bicycles or mopeds. High Occupancy Vehicle (HOV) facilities do not allow low occupancy vehicles. Certain trucks may not be allowed on road segments due to weight limits. The network database should contain information for each link about restrictions for each mode and vehicle type. This information is used to specify mode specific networks for traffic assignment and for mode specific shortest path building as interzonal impedance by every mode must be computed for mode choice and trip distribution models.

Number of lanes must be known for each link. The number of lanes of traffic is obviously a major factor in calculating link capacity. Parking along the roadway may affect the number of lanes if the curb lane is used as a travel lane at certain times of the day. If parking is not allowed during specific times, the number of lanes should reflect this for the network representing that time period in which parking is not allowed.

Link Capacity is a value describing the number of vehicles that can move through a link during the time period of interest. Link capacity is defined as a function of facility type and area type, as shown in the following table.

Facility Type / Area Type	CBD	Core Commercial	Core Residential	Urban Commercial	Urban Residential	Suburban Commercial	Suburban Residential	Rural
Freeway	2200	2200	2200	2200	2200	2200	2200	2200
Expressway	1500	1550	1550	1550	1600	1650	1750	1850
Class I Arterial	1100	1100	1150	1150	1200	1300	1400	1450
Class II Arterial	1050	1050	1100	1100	1150	1200	1250	1350
Class III Arterial	1000	1050	1050	1050	1100	1150	1200	1300
Class I Collector	850	850	850	850	900	950	1000	1050
Class II Collector	650	700	700	700	750	800	850	950
Local Street	650	700	700	700	750	800	850	950
High Speed Ramp	1600	1700	1800	1800	1900	1900	2000	2000
Low Speed Ramp	400	400	450	450	500	500	600	650
Centroid Connector	3150	3150	3150	3150	3150	3150	3150	3150

2.4 Turn-Penalty Data

Turn penalty and turn prohibition information must be specified for shortest path building and should therefore be assembled as part of the network development process. Turn penalties are specified by listing the three consecutive nodes involved in the turning movement. These three nodes are specified on a turn penalty record in a separate data file along with a time penalty, or in the case of a prohibited turn, a prohibition flag.

2.5 Highway Impedance

Highway network impedance is instrumental in highway traffic assignment models and in relating travel time on the network to traffic volumes. This section describes the functions used for computing impedance and the issues surrounding them.

The highway network link impedance attribute is the mechanism by which roadway congestion is represented in the travel demand model set. Impedance is derived from other link attributes by way of a volume delay function that computes travel time on a link as a strictly increasing function of link volume.

Volume delay functions are required to exhibit certain properties for valid use in equilibrium traffic assignment models. The functions must be:

- continuous functions over the continuous range of zero to total trips,
- continuously differentiable functions over the continuous range of zero to total trips, and
- strictly increasing over the continuous range of zero to total trips

These properties of the volume delay functions will guarantee that the equilibrium traffic assignment algorithm has an equilibrium solution, and that the equilibrium solution is unique. The practical implications of these mathematical properties are that the solution procedure will be a convergent procedure and each additional iteration will thus move closer to the true equilibrium solution. Also the unique solution which is moved toward in the solution procedure is consistent with a well defined notion of traveler route choice behavior – user optimal route choice behavior.

The volume delay functions are equations that adjust the speed on the links given a volume to capacity ratio and the previous speed. The volume delay functions were developed using a speed-flow relationship developed by Rupinder Singh, based on a speed-flow model originally developed by Rahmi Ak elik[1]. This speed-flow relationship is much more sensitive than the "classical" BPR curves. That is, at volume capacity ratios (v/c) of more than 1.0, the Ak elik formulation will show much lower speeds (and higher times) than the standard formulation. There are five formulations, for various facility types, plus a general formulation and a "do nothing" formulation for centroids. The volume delay functions used in the programs are as follows:

For facility types 1, 2 and 9:

$$T = T_0 + \{ D * 60 * 0.25 * (1/0.30) * [((v/c)-1) + \{ ((v/c)-1)^2 + (8 * 0.1 * (1/0.30) * ((v/c)/c)) \}]^{0.5} \}$$

For facility type 3:

$$T = T_0 + \{ D * 60 * 0.25 * (1/0.30) * [((v/c)-1) + \{ ((v/c)-1)^2 + (8 * 0.2 * (1/0.30) * ((v/c)/c)) \}]^{0.5} \}$$

For facility types 4 and 5:

$$T = T_0 + \{ D * 60 * 0.25 * (1/0.30) * [((v/c)-1) + \{ ((v/c)-1)^2 + (8 * 0.4 * (1/0.30) * ((v/c)/c)) \}]^{0.5} \}$$

For facility type 6:

$$T = T_0 + \{ D * 60 * 0.25 * (1/0.30) * [((v/c)-1) + \{ ((v/c)-1)^2 + (8 * 0.8 * (1/0.30) * ((v/c)/c)) \}]^{0.5} \}$$

For facility types 7, 8 and 10:

$$T = T_0 + \{ D * 60 * 0.25 * (1/0.30) * [((v/c)-1) + \{ ((v/c)-1)^2 + (8 * 1.6 * (1/0.30) * ((v/c)/c)) \}]^{0.5} \}$$

For facility type 12 (centroid connector):

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[1] For more detail see the paper "Improved Speed-Flow Relationships: Application to Transportation Planning Models" by Rupinder Singh. This paper can be found on the website www.mtc.dst.ca.us/datamart/research/boston1.htm.

$T = T_0$

Generic, or default, equation:

$$T = T_0 + \{ D * 60 * 0.25 * (1/0.30) * [((v/c)-1) + \{ ((v/c)-1)^2 + (8 * 0.4 * (1/0.30) * ((v/c)/c)) \}]^{0.5} \}$$

where:

T is link travel time,
T_0 is link free flow travel time,
D is link distance
v is link volume,
c is link capacity

3. Transit

This section describes the issues relevant to the development of a coded transit network for the Oahu transit system. Included in the discussion are network representation, transit supply, transit service level and coding issues.

3.1 Transit Network Representation

The transit network representation serves to relate transit travel characteristics including service levels, cost, and connectivity to the underlying zone system that may be used to represent travel demand. The transit network is used both to summarize interzonal transit travel characteristics and as a basis for loading transit trips to routes for estimating transit line patronage.

The transit network is thus more an abstraction of the transit service than of the underlying streets on which the service operates. The underlying streets are related to the highway network whenever possible such that a consistent spatial referencing system for both the roadway system and the transit service may be utilized. Development of a transit network thus consists of specifications of service levels, access and egress connections to the transit system and attributes of those access methods, and travel time relationships for the transit vehicles. The remainder of this section discusses these issues for the OMPO best practice model set.

3.2 Transit Supply Characteristics

The level-of-service experienced by a potential transit user is represented to the travel demand model set through a computerized representation of the system of routes and service levels. This “coded” transit network must be an accurate portrayal of the individual transit routes, fixed headways, and travel times that define that service. Consistency in representation methods across all alternatives is essential to insure that differences in travel times between those alternatives are accurate characterizations of service level differences, not simply differences in coding conventions.

3.2.1 Bus Routes and Coded Lines

A transit route in TheBus system is typically a set or series of services that operate generally in the same area and over the same streets, but which may offer variations in service origination or termination. The transit path-building algorithm, however, must be sensitive to the specific service level options available to each traveler between each origin/destination pair, which necessitates the representation of each of the variations within a route by means of a separately coded line. Similarly, not all routes, or subroutes, operate at all times over the course of an entire day. For example, express routes in particular generally operate only during the morning and afternoon peak periods. In order to properly reflect these differences, separate networks are created for each analysis time period used in the travel forecasting process.

A trade-off exists between the precision of representation of individual route variations actually operated and the transit service levels perceived by transit users. This tradeoff stems from the manner in which the transit path building algorithm measures the frequency of service between boarding and alighting locations. The algorithm recognizes that several lines operating in the same pattern offer a combined frequency of service that is the summation of the frequencies on each individual line. However, this recognition occurs only when the lines follow *exactly* the same routing; any departure from this routing, no matter how small, precludes an individual line from being included in the combined service computation. Therefore, the coded transit network lines do not attempt to represent relatively minor variations in routing or termini.

3.2.2 Headway Calculation

Specification of service frequency for each coded line is an extremely important aspect of the overall transit network coding process. As outlined above, service is differentiated both by delineation of individual lines (within routes) and also by analysis time period. The determination of a headway value for each line within a time period is related directly to the actual number of transit vehicle trips operated.

In the case of non-peak analysis time periods, the headway for a line is simply the number of hours in the mid-day time period divided by the total number of vehicle trips provided on that line during that period. Typical time periods for travel forecasting analysis are morning and afternoon peaks, mid-day, and evening. The resulting headway would then be applied to evening trips as well since all non-peak service is typically treated identically.

Unlike non-peak or base period service, which tends to be fairly evenly distributed over an entire period, peak period service may vary substantially within the peak time period. Express lines, for example, may provide relatively few vehicle trips over the entire period, but may be concentrated within a relatively short time interval. Assuming that these trips are appropriately targeted to the specific demand for peak period service, the perceived headway by riders (who will become familiar with the scheduling of the service) will be significantly better than the value implied by using a computation method identical to that for base period service. Therefore, peak headway calculations must be based upon the peak hour of service offered in the peak period, from which an appropriate peak hour headway may be calculated.

This approach to coding produces headway values appropriate for the ridership forecasting process, but typically overestimates peak resource requirements – vehicles, vehicle-hours, and vehicle-miles. A separate analysis of resource requirements is conducted in a post-processing environment to resolve this inconsistency.

3.2.3 Network Speeds

The network speed data for transit operations were originally coded for the Honolulu Rapid Transit project and were based on time-points along each route of the transit system determined from scheduled operations. The local bus speeds between time points were an average of all routes operating between those points. For fixed guideway and express bus service, the speeds were calculated by route segment for each specific route.

This network coding was done in anticipation of using the transit network specifically for transit service level estimation for use with an incremental logit mode choice model. For the model development project, transit speeds and travel times are more reflective of the highway speeds.

A transit travel time function relates estimated bus travel times on a link to highway speeds, estimated stops per mile, estimated proportion of buses stopping at each stop, and bus acceleration and deceleration characteristics. Space-mean highway speeds are taken directly from the highway traffic assignment model and are calibrated for local conditions. The resulting transit travel times are used by the transit path building program and thus affect transit in-vehicle time skims and transit trip assignment.

The transit travel times are based both on observed schedule times and are a function of the congested highway travel times for both peak and off-peak periods. For the base year, these two independent sources of transit time must be reconciled. This was done by comparing the model-estimated transit travel times to observed transit travel times for a set of transit segments. The results were summarized by facility type and a simple linear factor (a linear model with intercept equal to 0) was calculated for each link type. Freeway and expressway facilities, and ramps were not adjusted, that is, the congested highway travel time was used directly. Note also that a 0.17 minute (about 10 seconds) dwell time penalty was applied to each transit link; to represent time spent serving passenger access and egress at stops. The computed transit travel time factors are applied by facility type during transit path building. Table 3.1 shows these factors

Table 3.1: Transit Link Time Factors (Factors applied to congested highway link travel times)

Facility	Peak (based on AM Peak)	Off-Peak
Freeways and Expressways	1.0	1.0
Ramps	1.0	1.0
Arterial I	1.54	1.65
Arterial II	1.24	1.53
Arterial III	1.95	0.83
Collector I	1.22	1.50
Collector II	1.81	1.18
Local	0.83	1.41

3.2.4 Centroid Connectors

To relate transit supply characteristics to transit travel demand, the transit network must be associated with the travel activity measures represented by zonal aggregations of trips, or trips by traffic analysis zone (TAZ.) Descriptions of the zone system definition are found in Section 5 of this document. Each TAZ can be classified as being either within the walk access market or not within. This significantly simplifies the access coding as TAZs outside the "walk to transit " market need not have walk access connection links coded. Walk access links should be represented for all TAZs which have their zone centroid within one mile of any transit stop node, and then an access link coded for each stop node within one mile of the TAZ centroid. Travel time is computed by using a walk speed of 3 miles per hour and using the distance from centroid to stop node.

Auto access connectors are provided from every TAZ to the most logical transit stop nodes. These auto connector links represent the potential for either park-and-ride and/or passenger drop-off facilities. If a formally designated lot is available such as Hawaii Kai, then this stop-node would be included in the list of possible auto connector nodes. Most connections are to locations which may be characterized as informal lots which might be termini for express or local service or places of intersecting routes with multiple service routes. The travel time coded for each auto access connector is based upon the over-the-road travel time determined from the highway network.

Access to premium transit service follows a specific coding convention in order to facilitate the analysis of trips by access mode. Transfers between feeder bus and premium service is explicitly represented with a network link which represents walking from the bus stop to the premium service boarding area. Likewise, links are added to specifically account for time to walk to the boarding area for walk access trips from the surrounding area, and for drive access trips to account for the parking lot or drop off point to boarding area walk time.

4. Walk and Bicycle

Both the walk and bicycle level of service matrices are built using the highway network. In both cases, freeways and ramps are eliminated as possible links. A walk speed of 3 miles per hour and a bicycle speed of 7 miles per hour is used in constructing paths between zones and developing the required time and distance matrices for input to subsequent model steps. Walk trips are limited to 1.5 miles, while bicycle trips are limited to 3.5 miles.

5. Zone System

Traffic Analysis Zones (TAZs) represent the geographic stratification of a metropolitan planning study area. These geographic entities are generally formed of areas exhibiting similar land-use and socio-economic characteristics, thus yielding support to the assumption that trips are produced and attracted for travelers of similar trip-making characteristics. The complete set of TAZs defined for a metropolitan region constitutes the traffic analysis zone system or simply, the zone system.

There are various issues that affect the definition of the zone system. These factors include the following:

- Land-use
- Highway or street network connectivity
- Census geography
- Natural barriers
- Specific future development plans
- Designated Development Plan Areas, and
- Special generators

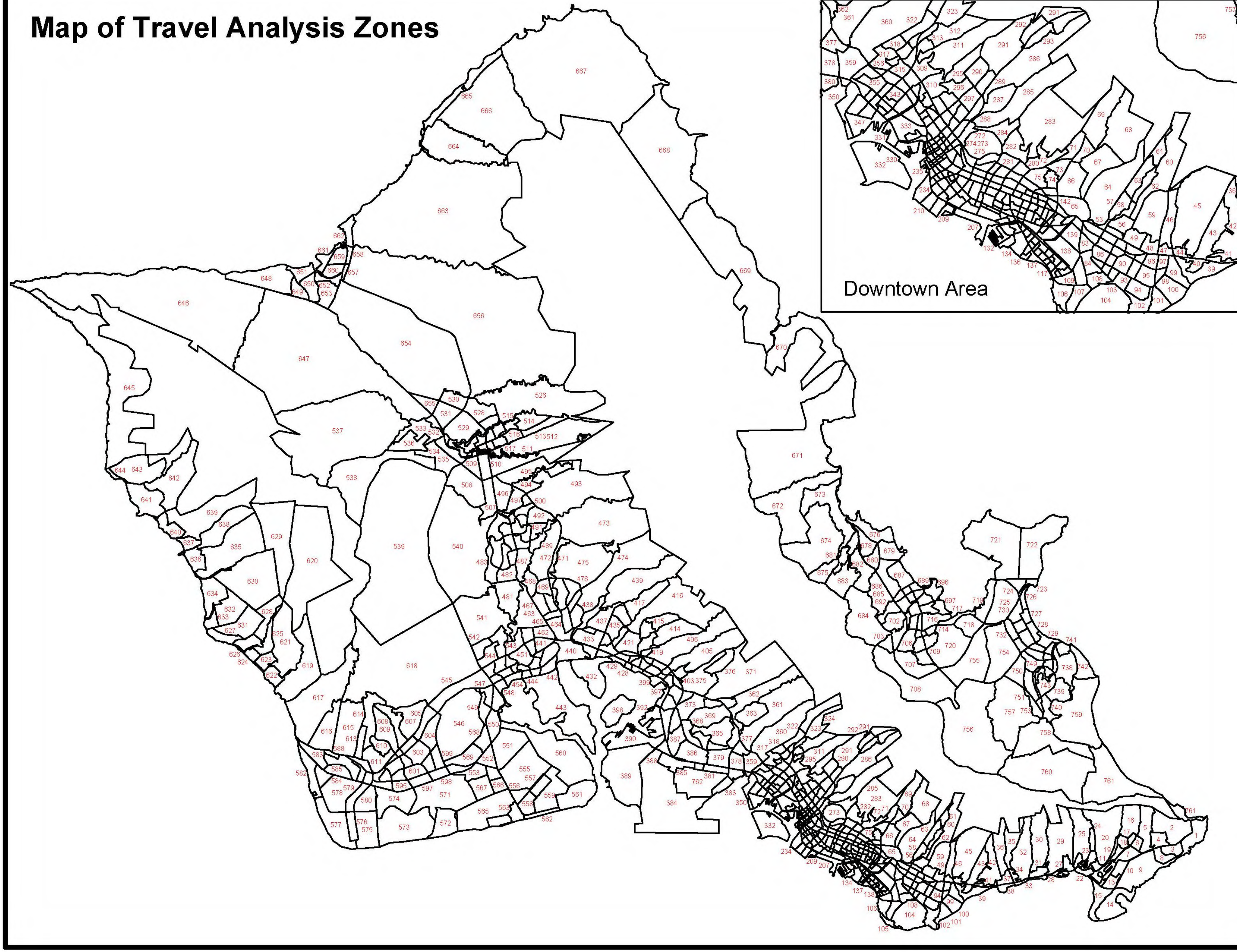
A brief description of the various issues listed above, indicating their role in the definition of the OMPO Model Zone System, is provided below. The final 762 zone system for Oahu was developed by disaggregating the previous 284 and 322 zone systems. A graphical depiction of the 762 zone system is shown in Figure 5-1. OMPO's standard 23 district system is shown in Figure 5-2.

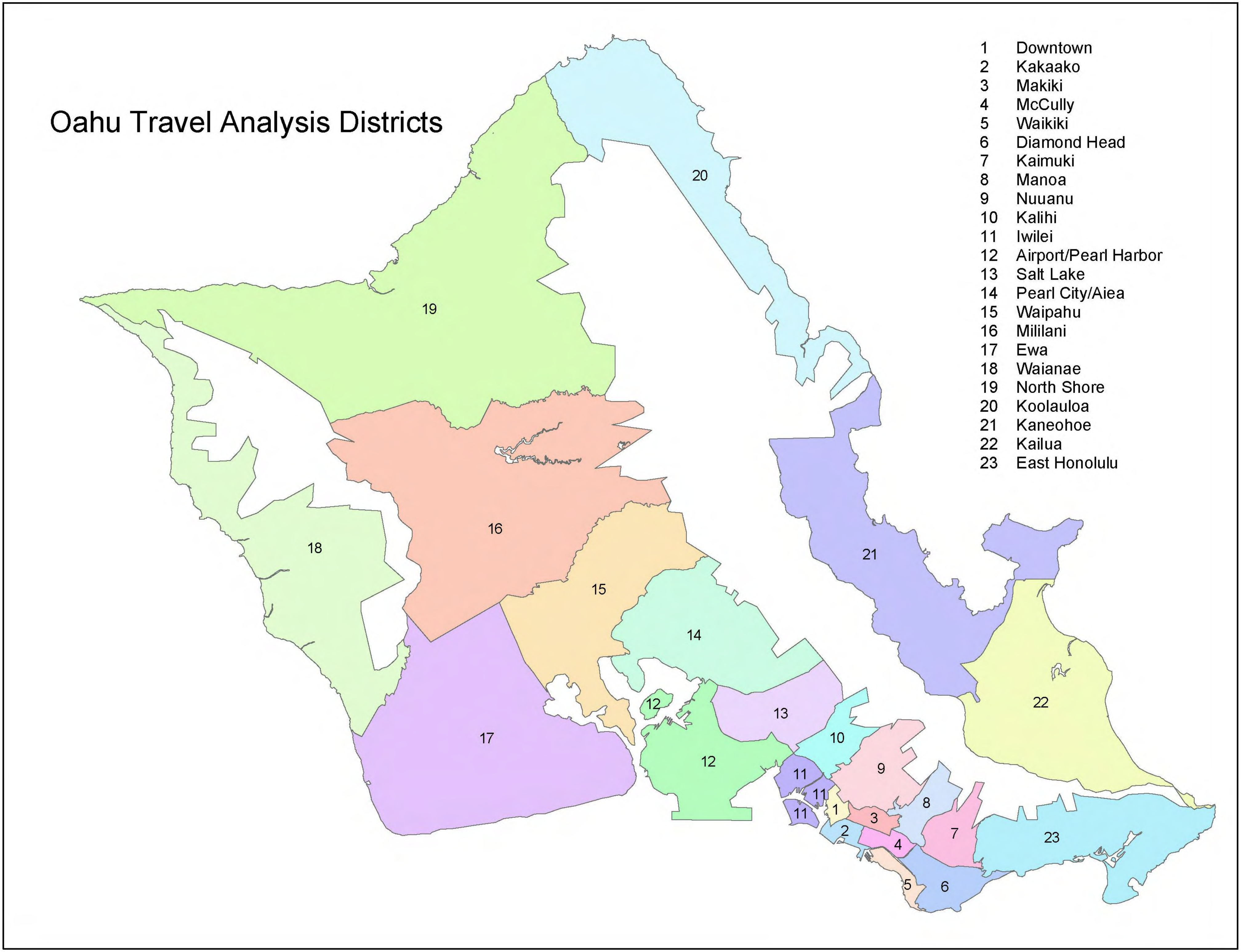
5.1 Land Use

The homogeneity of land use and socio-economic characteristics within each of the geographic areas constituting a traffic analysis zone is an important element in the definition of the zone system. As TAZs are the elemental unit by which travel demand is measured, homogeneity of travelers and activities requiring travel is important to substantiate the assumption of identical trip making characteristics for a zone.

However, availability of the land-use and socio-economic data at a particular level of disaggregation could be a constraint, given that collecting and maintaining this data continually may become overwhelming and unrealistic. On the other hand, various developing fringe areas with specific plans for development may have specific data available (e.g. Ewa/Kapolei, Central Oahu) that could be used in the definition of the zone system. Hence, a balance between maintaining a TAZ system with homogeneous land-use and socio-economic characteristics versus developing a zone system so detailed that data collection and maintenance efforts become overly cumbersome was achieved.

Map of Travel Analysis Zones




Oahu Travel Analysis Districts
1 Downtown
2 Kakaako
3 Makiki
4 McCully
5 Waikiki
6 Diamond Head
7 Kaimuki
8 Manoa
9 Nuuanu
10 Kalihi
11 Iwilei
12 Airport/Pearl Harbor
13 Salt Lake
14 Pearl City/Aiea
15 Waipahu
16 Mililani
17 Ewa
18 Waianae
19 North Shore
20 Koolauloa
21 Kaneohoe
22 Kailua
23 East Honolulu
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19
16
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5.2 Highway or Street Network Connectivity

TAZs are units for which aggregate travel demand is estimated. This demand is then allocated to the highway routes based on some behavioral hypothesis regarding the decisions made by travelers in choosing routes. A mechanism is needed to relate the zone to zone travel demand to the highway network. This mechanism is the use of network nodes called centroids, which represent the point of entry or exit at a zone, and network links called centroid connectors. These centroid connectors are attached to the highway network at locations that closely correspond to the locations at which local traffic enters the major street system. A certain level of network detail as well as zonal detail would be required to represent this process accurately. Hence, the zonal detail should be consistent with the detail of the highway network.

Care should be taken to ensure that proper connectivity to the highway network is ensured by matching the zonal detail with that of the highway network. If a major roadway facility runs through the zone dividing the zone into two distinct areas, care must be taken when specifying connectors from the zone to the network to ensure that physical boundaries are not crossed. This general rule is violated in the case of coastal highways (i.e., Kalanianaole Highway in East Honolulu or Kamehameha Highway in Koolauloa) for which a small portion of the zone makai of the highway is not split from the mauka portion of the zone.

5.3 Census Geography

The United States Bureau of the Census has defined various levels of aggregate areas at which key demographic and travel information are collected, summarized, and published every ten years. Two such relevant areas are the census tracts and census blocks. It is important that the zone system set up for the OMPO model not violate this geography. The demographic and Journey-to-Work information published by the Census Bureau for the 1990 Census are provided at particular levels of census geography. Since these pieces of information are important inputs both during the development and validation steps of the modeling process, the TAZ system definition should be consistent with census geography. To the extent possible, consistency was maintained with the previous 284 and 322 zone systems developed by OMPO.

5.4 Natural Barriers

Natural barriers like mountain ridges and gorges with potential for development on either side covering particular watershed areas were given due consideration in the definition of the zone system. This is especially true in the Central Oahu region. However, all areas in the modeled region were evaluated to take into consideration the presence of natural barriers since both current as well as future access to these areas would be most definitely affected by them.

5.5 Specific Future Development Plans

There are certain large areas on Oahu that have specific development plans proposed or currently being studied. These include Ewa/Kapolei and Central Oahu. Such areas may be disaggregated to more accurately reflect development patterns consistent with the highway network detail. Since information on both development locations and quantities as well as their connectivity to the highway network are available, they may lend themselves as appropriate candidates for more detailed treatment in the models.

5.6 Designated Development Plan Areas

The City and County of Honolulu's General Plan has stratified the island of Oahu into eight distinct areas called Development Plan Areas. The correspondence between the 284 zone system and the Development Plan Areas is shown in Table 5-1. It can be seen from Table 5-1 that two zones, one each in Central Oahu and Koolauloa fall partly in their adjacent development plan areas. To facilitate production of summary statistics of various planning parameters and resultant travel patterns associated with the development policies in the region, the final zone system honors the boundaries of these eight Development Plan Areas and thus nest within them.

Table 5-1 - Current Zone System Correspondence to Development Plan Areas

Number	Development Plan Area	Traffic Analysis Zone (TAZ) Numbers
1	PUC	1 - 189
2	Ewa	240 - 262
3	Central Oahu	226 - 231, 239{1}, 263 - 284
4	East Honolulu	190 - 198
5	Koolaupoko	199 - 220
6	Koolauloa	221 - 223{2}
7	North Shore	224, 225, 232, 233
8	Waianae	234 - 238

Note: {1} - Part of zone 239 is in Ewa.
{2} - Part of zone 223 is in North Shore.

5.7 Special Generators

Special generators, from a transportation modeling perspective, are those land uses that have associated with them spatial and temporal travel patterns very different from the rest of the region. Furthermore, the planning parameters associated with these atypical activity centers are different from those used for the more commonly defined activity centers. In some cases such as with universities, unique information is available which is quite useful in modeling, e.g. student enrollment and home locations. Some of the relevant special generators in the OMPO modeling region include the following:

Large military bases and installations

Large schools

Colleges/universities

Large shopping centers (particularly the Ala Moana Shopping Center)

Resort areas including the hotels along the coastline

Honolulu International Airport, and

Harbors

The specification of the zone system considered the above special generators of trips to facilitate the estimation and use of special trip generation/trip making characteristics associated with them, in the modeling process.

C. Models of Resident Travel

1. Overview

This part of the documentation describes the trip-based demand models for resident travel. The models comprise the central sequence of steps that together produce resident person-trip tables for assignment to the highway and transit networks.

The models stratify resident travel by 11 trip purposes:

- Journey-to-Work – Home-Based Work
- Journey-to-Work – Home-Based Non-Work
- Journey-to-Work – Work-Based Non-Work
- Journey-to-Work – Non-Home-Based, Non-Work-Based
- Journey-at-Work – Work-Based
- Journey-at-Work – Non-Work-Based
- Non-Work-Related – Home-Based College
- Non-Work-Related – Home-Based K-12 School
- Non-Work-Related – Home-Based Shopping
- Non-Work-Related – Home-Based Other
- Non-Work-Related – Non-Home-Based

Examples of these trip purposes are described as follows:

> A person leaves his home and goes to work (Journey-to-Work – Home-Based Work).
>
> A person leaves his home heading toward work and stops at the dry cleaner (Journey-to-Work – Home-Based Non-Work). He continues on and then stops for a coffee (Journey-to-Work – Non-Home-Based, Non-Work-Based). He continues on and reaches work (Journey-to-Work – Work-Based Non-Work).
>
> A person leaves work and goes to lunch (Journey-at-Work – Work-Based). He continues on to shop (Journey-at-Work – Non-Work-Based). And then returns to work (Journey-at-Work – Work-Based).
>
> A person leaves his home and goes to college (Non-Work-Related – Home-Based College).
>
> A person leaves his home and goes to high school (Non-Work-Related – Home-Based K-12 School).
>
> A person leaves his home and goes shopping (Non-Work-Related – Home-Based Shopping). He continues on to a restaurant (Non-Work-Related – Non-Home-Based). And then returns home (Non-Work-Related – Home-Based Other).

These component models form the core of the full model set depicted in Figure 1–1.

- The Vehicle Ownership model estimates the distribution of vehicle-ownership levels by each type of household. It takes as input a distribution of households in each zone by their demographic characteristics, as produced by the land use model.

- The Trip Generation model predicts the trip-productions and trip attractions, stratified by 11 trip purposes, based on calibrated trip-rates applied to the numbers and characteristics of households and jobs in each zone on the island. The Vehicle-Ownership and Trip Generation models are shown together in the flowchart because they are applied together in a single computer program.

- The Trip Distribution model applies a logit formulation to develop a zone-to-zone trip table for each trip purpose using the predicted trip productions and trip attractions in each zone together with zone-to-zone highway travel times derived from the highway network. The distribution model for several purposes uses segmentation by vehicle-ownership level. The model considers all travel over the average weekday for each trip purpose, using peak-period highway times for travel to/from work and school and off-peak highway times for all other trip purposes.

- The Mode Choice model applies a nested-logit formulation to estimate the shares of each zone-to-zone travel market that will use each of 10 competing travel options. The options include alternative modes (auto, transit, and non-motorized travel), occupancies (1, 2, and 3+ per vehicle), transit access-modes (walk, park/ride, and kiss/ride), transit paths (local, premium, and guideway), walking, and bicycling. The model considers a large number of characteristics of the trip, the traveler, and the competing travel options to estimate the shares attracted to each option. Like the Trip Distribution model, the Mode Choice model considers travel for an entire average weekday for each trip purpose, using peak travel conditions for commuter travel and off-peak conditions for all other trip purposes.

- The Time-of-Day / Direction model accomplishes several steps necessary to prepare trip tables for assignment to the highway and transit networks. First, it allocates the daily trip tables developed by the Trip Distribution model for each trip purpose across the individual time-periods of the day. Second, for the person-trips choosing one of the automobile options, it converts trip tables from production-attraction format to origin-destination format and computes vehicle trips based on the three occupancy levels. Finally, the model aggregates the resulting trips across trip purposes to produce time-period specific tables for assignment to the highway and transit networks. (See Guide to Model Form, Section B. Transportation System, Chapters 2. Highway and 3. Transit.)

Sections 2 through 6, respectively, describe the structure, parameters, and development of each of the vehicle ownership, trip generation, trip distribution, mode choice, and time-of-day / direction components.

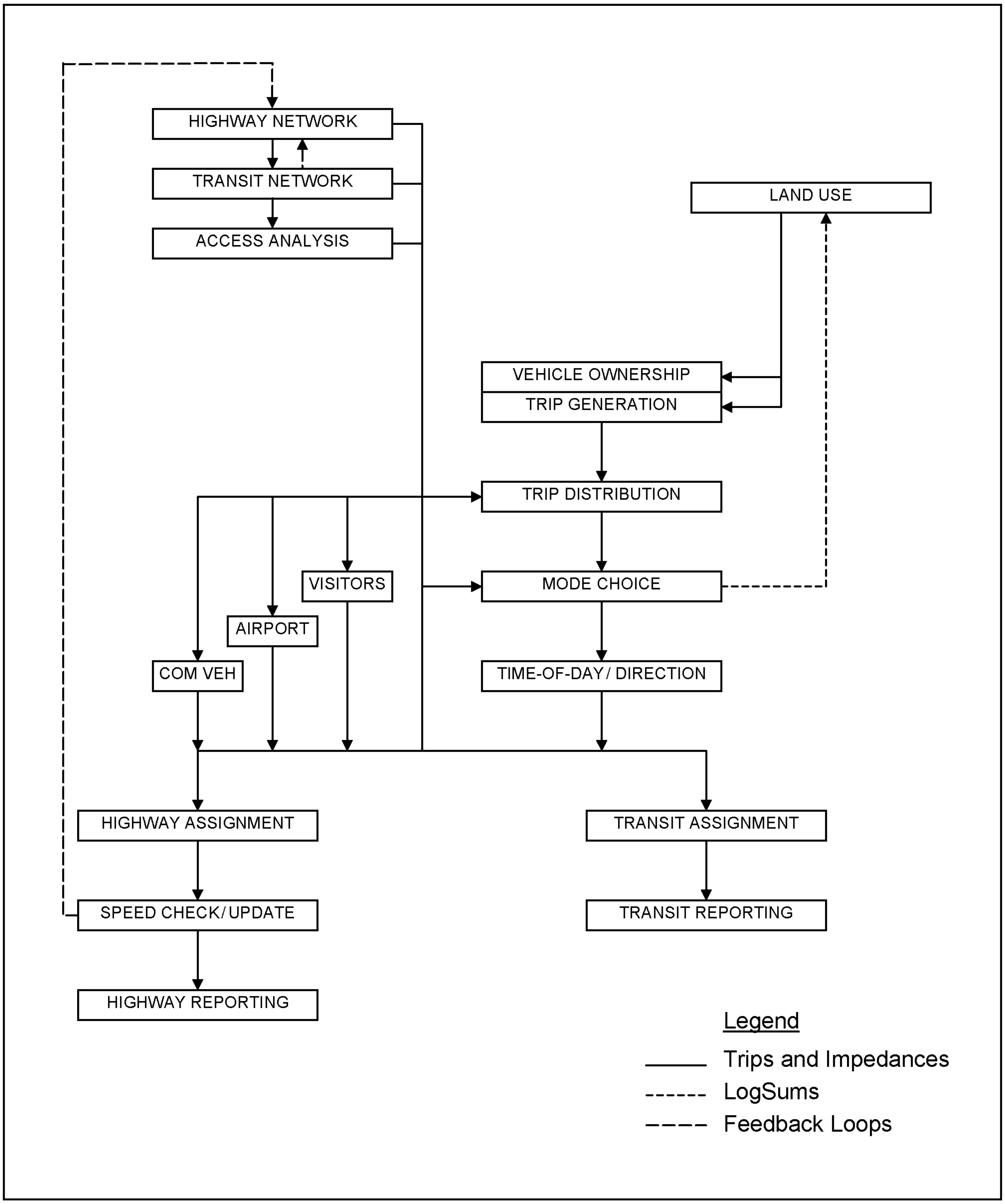


Figure 1–1

Structure of the OMPO Forecasting Procedures for Land-Use and Transportation

2. Vehicle-Ownership Model

The Vehicle-Ownership model provides a method to describe the households in each Traffic Analysis Zone (zone) in terms of their joint distribution by household size, household income, and number of vehicles. The model employs a logit based choice model to forecast vehicle-ownership based on socio-demographic variables.

2.1 Description

The trip production component of Trip Generation requires as input the joint distribution of households by income, number of persons (size), and vehicle-ownership within each zone. The vehicle-ownership model completes this cross-classification given the household distribution from the land use model.

Table 2.1-1 summarizes the key attributes of the vehicle-ownership model.

The households input from the land-use model are distributed jointly by size, income, and number of workers. These categories define the status of each person in each household. For example, a 2 person 1 worker household implies that there is one worker and one non-worker in the household.

Four steps combine to predict the vehicle-ownership category for each class of households in the input joint distribution.

First, the number of persons "sufficed" by each vehicle-ownership alternative is computed. The number of persons sufficed is a variable for the vehicle-ownership model and is best illustrated with a couple of examples. These variables indicate the number of persons in each category for which there are a sufficient number of vehicles to dedicate a vehicle to each person. The computation of these variables assigns the available vehicles to persons in order of their assumed importance: workers first then non-workers. Consider the following households.

Household composition: 2 workers and 1 non-worker

Sufficiency variables by alternative:

Alternative: Sufficient for:	0 vehicles	1 vehicle	2 vehicles	3+ vehicles
Workers	0	1	2	2
Non workers	0	0	0	1

Household composition: 1 worker and 2 non-workers

Sufficiency variables by alternative:

Alternative: Sufficient for:	0 vehicles	1 vehicle	2 vehicles	3+ vehicles
Workers	0	1	1	1
Non workers	0	0	1	2

Table 2.1-1

Key Attributes of the Vehicle-ownership Model

Inputs

- Joint distribution of households by size (1,2,3,4,5+ persons), income (0-20k, 20-40k, 40-75k, 75k+), and number of workers (0,1,2+ workers) per zone.
- Vehicle importance for each zone.
- Density for each zone, calculated as the sum of population plus jobs (employment) in the zone, divided by the area of the zone in acres[1].
- Vehicle-ownership model coefficients.
- Employment, households, and area of zone.

Outputs

- Households classified jointly by income class, household size, and number of vehicles.

Method

- The input joint distribution categorizes households into combinations of workers, non-workers, and income categories.
- Sufficiency variable is calculated for each combination of number of workers, number of non-workers, and income categories.
- Density measure is calculated from employment, population, and area of zone.
- Using the calculated sufficiency variables, density variable, input vehicle importance measures, and vehicle-ownership model coefficients, the percentage breakdown of households into vehicle-ownership classes is computed and applied to the input households.
- The end result is a distribution of household by number of persons, income category, and number of vehicles for each zone.
- The vehicle-ownership model classes are 0, 1, 2, 3+ vehicles but the trip generation requires a 0, 1, and 2+ vehicles class structure; therefore, the households are aggregated such that the 2 and 3+ vehicle classes are combined.

[1] The total area of the zone is used, calculated using GIS. It should be noted that the 762-zone system does not include the Forest Reserve areas on Oahu within any zone.

The second step is to compute the density variable from the zonal data. This is simply computed as the sum of employment plus population for the zone divided by the zone's area in acres. The vehicle-ownership model density variable is a dummy variable with a 1 representing densities greater than 100 jobs plus population per acre and 0 otherwise. The objective of this variable is to measure the disutility associated with garaging vehicles. The hypothesis is that at higher densities, the prospect of garaging vehicles becomes more difficult.

Several different density variables were constructed. Continuous densities, density dummy variables with various cutoff values, and retail employment within 1 mile were experimented with. None of the alternate density formulations provided much improvement in loglikelihood and therefore the measure that is most easily implemented and understood is used.

The third step is to compute the vehicle importance measure. The utility of owning a vehicle to an individual household depends on the importance of household vehicles in providing accessibility to activities. To represent vehicle-importance, a useful class of measures can be derived from gravity-like formulations. The accessibility provided to households in a given zone by a particular mode can be expressed as:

(Eq. 1) $$\text{Access}_{i,m} = \text{SUM}_z\ [\ f(I_{i,z,m}) \times S_z\ ]$$

where i is a zone of residence zone for which the access measure is computed;

m is the mode of interest;

z represents all possible destination zones;

$I_{i,z,m}$ is the travel impedance between zones i and z via mode m; and

S_z is a measure of the size of activity-opportunities in zone z such as total employment.

If the function $f(I_{i,z,m})$ is the square of the impedance, then it is effectively the denominator of the classic gravity model. If it is the exponential of the impedance, it is analogous to the denominator of a multinomial-logit destination-choice model. In either case, the importance of a vehicle for a particular zone can be defined as proportionate to the fraction of total accessibility provided by a personal vehicle:

(Eq. 2) $$\text{Importance}_{i,a} = \frac{\text{Access}_{i,a}}{\text{Access}_{i,a} + \text{Access}_{i,w} + \text{Access}_{i,t}}$$

where a, w, and t represent vehicle, walking, and transit, respectively. The importance measure for automobiles is therefore 1.0 for households in an outlying zone where no accessibility is provided by walking or transit. The measure is 0.33 in a zone where the accessibility terms for walking and transit are each equal to the term for the vehicle. This step is performed outside of the trip generation program (TG.EXE) using MINUTP Matrix.

The fourth step takes the sufficiency coefficients, the input vehicle importance measure, the calculated density, and income for the class of households of a zone and computes the probabilities of choosing 0, 1, 2, and 3+ vehicles. The probabilities are applied to the number of households in each particular class of each zone. The process is repeated for all household classes. Households in each vehicle-ownership class are summed over all household classes for the zone so that the resulting household distribution is by income (0-20k, 20-40k, 40-75k, 75k+), size (1,2,3 or 4, 5+ persons), and number of vehicles (0,1,2+ vehicles).

The resulting three-way joint distribution for each zone of households by their income, size, and vehicle-ownership forms one of the two main inputs to the Trip Generation model. Because the vehicle-ownership model and the trip generation model are applied in the same program (TG.EXE), the joint distribution is transferred internally and is not output directly.

2.2 Development

The vehicle-ownership model was estimated using the 1995 Oahu Household Interview Survey (HIS) data. The model structure is based on the 1999 research paper titled "Vehicle-ownership Model using Family Structure and Accessibility with Application to Honolulu, Hawaii" by James M. Ryan and Gregory C. Han (Transportation Research Board, Washington, D.C., Transportation Research Record No. 1676).

Model Structure

The model structure described in the above research paper entailed detail in its input variables that could not be provided with the aggregate data for application. Therefore, for application the model structure needed to be simplified. The structure of the model remains a multinomial-logit model with the alternatives being 0, 1, 2, or 3+ vehicles. The structure of the utility functions is shown below:

$U(n,h) = k_n + b_n DENSDUMMY_i + c_{n,inc} INC_h + d_m(SUFF_{m,n})(AIMP_i)$

where $U(n,h)$ is the utility for a specific number of vehicles, n, owned by household h;

k_n is a vector of alternative-specific constants that represent (largely) the ownership costs for n vehicles;

$DENSDUMMY_I$ is a dummy variable that is derived from the density of the residence zone i of household h, computed as the sum of population plus jobs (employment) in i divided by the area of i in acres. A value of 1 is assigned to the zone if the density is greater than 100 population plus jobs per acre and a 0 otherwise;

INC_h is the income-class of household h, from one of four classes defined (from low to high) to match the classes used in the trip generation model (0-20k, 20-40k, 40-75k, 75k+);

$SUFF_{m,n}$ is a matrix of member-class- and alternative-specific variables that identify the number of household members in member-class m for whom n vehicles is sufficient to provide exclusive access to one of the vehicles. In application only two member classes are used: workers and non-workers;

$AIMP_i$ is the importance, for all households in zone i, of having a vehicle to provide access to away-from-home activities for household members, bounded by 1.0 where vehicle travel is the only means of access and (theoretically) by 0.0 where no vehicle travel is possible;

b_n is an alternative-specific vector of coefficients that represent the (dis)utility of maintaining n vehicles for households in a zone with density $DENS_i$;

$c_{n,inc}$ is an alternative- and income-specific matrix of coefficients that represent the effect of household income in offsetting ownership costs;

d_m is a member-class-specific vector of coefficients that represent the utility gained by a household by providing a vehicle to a household member in member-class m; and

Resulting Coefficients

Table 2.2-1 summarizes the estimated coefficients for the vehicle-ownership model.

Table 2.2-1

Vehicle-ownership Model Coefficients

Attributes		Number of Vehicles 0	1	2	3+
Costs					
	Constant	---	-1.00	-2.66	-5.22
	High density at residence zone dummy	---	-0.70	-1.83	-1.94
Income					
	Income class 1 (0-20k)	---	---	---	---
	Income class 2 (20-40k)	---	1.38	1.91	1.81
	Income class 3 (40-75k)	---	1.81	3.45	3.59
	Income class 4 (75k+)	---	2.48	4.81	5.58
Sufficiency x vehicle-importance (4)					
	Workers	---	2.91	2.91	2.91
	Non Workers	---	1.55	1.55	1.55

All of the coefficients were estimated from the 1995 Oahu Household Interview Survey (HIS) data sample except for the constants. The constants were calibrated so that the estimated households in the base year had aggregate vehicle-ownership shares that matched the aggregate shares from the 1995 Oahu HIS data. This was done by using aggregate 1995 HIS data as the input to the vehicle-ownership model and comparing the predicted shares with the observed 1995 HIS data. The following table, Table 2.2-2 illustrates the calibration results by Sub-PUMA (as defined for the 1990 Census) as well as in total. The estimated vehicle-ownership shares in total matches the observed shares from the 1995 Oahu diary data thereby indicating that the constants are calibrated. The estimated shares by Sub-PUMA also match fairly well with the observed Oahu diary data shares.

Table 2.2-2

Vehicle-ownership Validation against Census PUMS

Sub-PUMA	Observed % Households from 1995 Diary Data					Estimated % Households from 1995 Diary Data				
	Vehicles					Vehicles				
	0 veh	1 veh	2+ veh	Total	Avg veh	0 veh	1 veh	2+ veh	Total	Avg veh
Pearl City / Aiea	3.6%	27.5%	68.8%	100.0%	2.20	4.6%	30.5%	64.8%	100.00%	2.12
Ewa / Waipahu	10.5%	28.7%	60.7%	100.0%	1.99	7.4%	32.9%	59.7%	100.00%	2.00
Hawaii Kai / Aina Haina	4.2%	33.0%	62.8%	100.0%	2.09	7.8%	31.0%	61.3%	100.00%	2.03
Downtown / Waikiki	26.2%	48.3%	25.5%	100.0%	1.20	20.5%	46.6%	32.9%	100.00%	1.39
Kalihi / Airport	12.3%	39.2%	48.5%	100.0%	1.75	10.7%	37.6%	51.7%	100.00%	1.82
Waianae / North Shore	6.5%	36.3%	57.1%	100.0%	1.96	9.2%	34.2%	56.6%	100.00%	1.93
Windward / Kailua	5.7%	29.4%	64.9%	100.0%	2.11	6.7%	32.7%	60.6%	100.00%	2.02
Total	11.5%	36.4%	52.1%	100.00%	1.82	11.1%	36.7%	52.2%	100.00%	1.83

3. Trip Generation

This component of the travel models estimates trip-ends for each zone as a function of the activity in that zone as represented by the number of households, employees, and students. The resulting trip-end estimates are characterized by trip purpose for both trip productions and trip attractions.

3.1 Description

The Trip Generation model comprises two component models, one that estimates trip productions in each zone and a second that estimates trip attractions in each zone. It also includes a balancing step that ensures internal consistency among the regionwide trip-end totals. Table 3.1-1 summarizes the key characteristics of the Trip Generation model.

Trip Productions

The trip-production models estimate the number of trips produced in each zone, regardless of travel mode; consequently, the productions include trips made by walking and bicycling. The form of the production models is a set of look-up tables of per-household trip-production rates, stratified by household income, household size, and vehicle ownership. It is important to note that the income effects on trip rates are in the form of a relative measure of income, or income quartiles[1].Table 3.1-2 presents the estimated rates for the work-related purposes, while Table 3.1-3 presents the estimated rates for the non-work-related trip purposes. It is important to note that the total trip rates presented in both tables are for trips across *all* purposes. In application, the rates for each of the eleven trip purposes are multiplied by the number of households in each zone, with both rates and households stratified by household size, vehicle ownership, and income. For non-home-based trip purposes, summation of trip-ends estimated for households in each cell of this joint distribution yields the estimated number of trip-productions in each zone for each purpose. For home-based trip purposes, the vehicle-ownership distribution of trip-ends is preserved for use by the Trip Distribution and Mode Choice models.

Trip Attractions

The trip attraction models are tables of trip-rates stratified by trip purpose, attractor-type, and, for some purposes, area type. An attractor-type is a characteristic of each zone that is most closely associated with each trip purpose: total employment, retail employment, enrolled students by school-type, and total households. For example, retail employment is the appropriate attractor-type for shopping trips. Attraction rates are defined for multiple attractor-types for 6 of the 11 trip purposes. The nature of the activity at the attraction end defines the attractor-type for each trip in any of these 6 purposes. For example, trips from home to eat out, drop off kids at school, visit friends, or take care of personal business would all be classified as non-work-related home-based other (NWR-HBO) trips (assuming they aren't made on the journey-to-work). Each

[1] For the base year of 1995, the household income break points are <$20,000, $20,000-$40,000, $40,000-$75,000, and >$75,000. For future year forecasts, the ratio of the mean income for the zone and the mean income for the region is used to categorize regional households into approximately equal quartiles.

has a different attractor-type however, so NWR-HBO attraction rates apply to several attractor-types. The attractor types for each trip purpose are shown in Table 3.1-4. The incorporation of area type in trip attractions rates measure the implications of population and employment density on rate levels. For example, in zonal areas where the employment density is high, there would be a higher propensity for making journeys while at work. In other words, the use of area type measures the impact of urban form on trip making.

Table 3.1-5 presents attraction rates by trip purpose, attractor type, and area type. These rates were developed using expanded trip information from the Home-Interview survey and total employment information stratified by area type. To produce attractions per zone for each trip purpose, these attraction rates are multiplied by the number of attractors of that type, then summed across attractor types.

Table 3.1-1

Key Characteristics of the Trip Generation Models

Inputs

- Households per zone stratified by income, size, and vehicle ownership
- Attractors per zone by type (total employees, retail employees, students)
- Trip production rates by household size, vehicle ownership, income, and trip purpose
- Trip attraction rates by attractor type, area type (for some attractors), and trip purpose
- Flags to indicate whether to balance to productions or attractions for each purpose

Outputs

- Zone-level trip productions and trip attractions by trip purpose

Method

- Application of trip-production rates to individual classes of households
- Summation across household classes for each purpose
- Application of trip-attraction rates to attractor types
- Summation across attractor types for each purpose
- Regionwide balancing of total trip ends to ensure consistency between total productions and total attractions for each trip purpose

Table 3.1-2
Trip Rates: Total and Work-Related Purposes

Vehicles
Zero

	Household Income				Average
	<$20k	$20-40k	$40-75k	>$75k	
# Persons					
One					
Total	3.51	3.93	3.37	2.91	3.53
JTW: HBW	1.05	.56	.85	.96	.79
JTW: HBNW	.34	.29	.13	.02	.20
JTW: NB	.04	.33	.10	.00	.16
JTW: WB	.68	.30	.20	.11	.29
JAW: NB	.00	.03	.01	.08	.02
JAW: WB	.27	.09	.21	.04	.15
Two					
Total	4.45	5.50	3.83	5.69	4.88
JTW: HBW	1.17	1.47	1.79	1.34	1.51
JTW: HBNW	.39	.30	.23	.28	.29
JTW: NB	.43	.00	.08	.00	.08
JTW: WB	.29	.30	.23	.28	.28
JAW: NB	.00	.00	.00	.00	.00
JAW: WB	.85	.19	.02	.32	.24
Three or Four					
Total	7.75	8.28	7.55	5.27	7.47
JTW: HBW	.79	1.81	1.11	1.29	1.30
JTW: HBNW	.00	.09	.09	.42	.13
JTW: NB	.00	.05	.00	.00	.02
JTW: WB	.00	.09	.09	.42	.13
JAW: NB	.00	.00	.00	.00	.00
JAW: WB	.00	.00	.16	.00	.06
Five or more					
Total	8.06	4.00	9.45	10.61	9.49
JTW: HBW	.32	2.00	1.88	.56	.92
JTW: HBNW	.11	.00	.00	.56	.25
JTW: NB	.00	.00	.00	.00	.00
JTW: WB	.21	.00	.00	.00	.06
JAW: NB	.00	.00	.00	.00	.00
JAW: WB	.00	.00	.00	.00	.00
Total					
Total	4.92	5.00	4.51	5.17	4.85
JTW: HBW	.95	1.01	1.18	1.04	1.07
JTW: HBNW	.27	.27	.14	.23	.22
JTW: NB	.12	.19	.07	.00	.11
JTW: WB	.43	.27	.18	.18	.25
JAW: NB	.00	.01	.00	.03	.01
JAW: WB	.32	.11	.14	.10	.15

Source: 1995 OMDP HIS CVF970307

Table 3.1-2 (con't)
Trip Rates: Total and Work-Related Purposes

Vehicles
One

	Household Income				Average
	<$20k	$20-40k	$40-75k	>$75k	
# Persons					
One					
Total	3.90	4.19	4.02	3.80	4.01
JTW: HBW	.87	.97	1.16	.89	1.01
JTW: HBNW	.31	.33	.24	.31	.29
JTW: NB	.16	.13	.10	.11	.12
JTW: WB	.32	.31	.40	.34	.35
JAW: NB	.01	.01	.03	.01	.02
JAW: WB	.33	.43	.45	.43	.42
Two					
Total	7.07	7.24	6.61	7.16	6.99
JTW: HBW	1.56	1.29	1.53	1.71	1.48
JTW: HBNW	.69	.54	.43	.42	.50
JTW: NB	.30	.24	.14	.12	.19
JTW: WB	.66	.54	.45	.49	.51
JAW: NB	.00	.01	.03	.00	.01
JAW: WB	.45	.49	.49	.86	.55
Three or Four					
Total	8.56	8.72	9.50	11.65	9.57
JTW: HBW	1.86	1.71	1.81	1.84	1.79
JTW: HBNW	.46	.44	.48	.60	.49
JTW: NB	.24	.12	.20	.30	.20
JTW: WB	.48	.44	.69	.79	.61
JAW: NB	.05	.03	.06	.03	.04
JAW: WB	.28	.22	.41	.54	.36
Five or more					
Total	10.03	15.31	16.59	14.58	14.94
JTW: HBW	2.15	1.88	2.25	3.22	2.22
JTW: HBNW	.27	.59	.36	.29	.42
JTW: NB	.19	.17	.17	.12	.16
JTW: WB	.36	.61	.36	.29	.44
JAW: NB	.00	.04	.05	.01	.04
JAW: WB	.17	.21	.45	.51	.34
Total					
Total	6.65	7.54	7.62	7.97	7.52
JTW: HBW	1.46	1.36	1.57	1.60	1.49
JTW: HBNW	.46	.46	.38	.44	.43
JTW: NB	.23	.17	.15	.17	.17
JTW: WB	.47	.46	.49	.52	.48
JAW: NB	.01	.02	.04	.01	.02
JAW: WB	.34	.38	.45	.61	.44

Source: 1995 OMDP HIS CVF970307

Table 3.1-2 (con't)
Trip Rates: Total and Work-Related Purposes

Vehicles
Two or more

	Household Income				Average
	<$20k	$20-40k	$40-75k	>$75k	
# Persons					
One					
Total	3.44	4.30	4.37	4.98	4.21
JTW: HBW	.90	1.25	1.12	2.84	1.28
JTW: HBNW	.51	.36	.46	.05	.40
JTW: NB	.49	.32	.31	.00	.32
JTW: WB	.63	.36	.55	.05	.46
JAW: NB	.00	.02	.00	.00	.01
JAW: WB	.05	.16	.12	.81	.19
Two					
Total	8.13	7.62	6.90	7.11	7.33
JTW: HBW	2.05	1.86	2.06	1.60	1.92
JTW: HBNW	.68	.52	.50	.26	.49
JTW: NB	.36	.39	.19	.09	.26
JTW: WB	.78	.55	.53	.33	.54
JAW: NB	.09	.07	.03	.01	.05
JAW: WB	1.33	.76	.70	.55	.77
Three or Four					
Total	11.78	11.85	12.26	11.49	11.95
JTW: HBW	2.20	2.28	2.43	2.21	2.32
JTW: HBNW	.78	.97	.95	.75	.90
JTW: NB	.57	.37	.46	.29	.42
JTW: WB	.85	.85	.97	.78	.89
JAW: NB	.11	.05	.06	.05	.06
JAW: WB	.75	.73	.98	.76	.84
Five or more					
Total	17.07	16.94	14.65	16.61	16.06
JTW: HBW	3.47	3.64	3.10	3.45	3.39
JTW: HBNW	.56	.86	.98	.73	.85
JTW: NB	.39	.32	.48	.28	.38
JTW: WB	.60	.95	1.11	.73	.93
JAW: NB	.00	.13	.00	.03	.05
JAW: WB	.71	.53	.62	.57	.59
Total					
Total	11.78	11.82	11.20	11.21	11.49
JTW: HBW	2.43	2.48	2.45	2.31	2.44
JTW: HBNW	.69	.81	.82	.59	.77
JTW: NB	.46	.36	.39	.22	.37
JTW: WB	.76	.78	.88	.63	.79
JAW: NB	.08	.07	.04	.03	.05
JAW: WB	.87	.68	.80	.66	.75

Source: 1995 OMDP HIS CVF970307

Table 3.1-2 (con't)
Trip Rates: Total and Work-Related Purposes
Total

	Household Income				Average
	<$20k	$20-40k	$40-75k	>$75k	
# Persons					
One					
Total	3.74	4.10	3.84	3.61	3.88
JTW: HBW	.92	.84	1.06	.99	.96
JTW: HBNW	.34	.32	.22	.22	.27
JTW: NB	.16	.21	.11	.07	.15
JTW: WB	.45	.31	.35	.26	.34
JAW: NB	.00	.02	.02	.03	.02
JAW: WB	.29	.30	.35	.34	.32
Two					
Total	7.33	7.22	6.52	7.00	6.95
JTW: HBW	1.76	1.57	1.82	1.63	1.69
JTW: HBNW	.66	.51	.45	.33	.48
JTW: NB	.34	.28	.16	.09	.22
JTW: WB	.68	.52	.47	.40	.50
JAW: NB	.04	.04	.03	.00	.03
JAW: WB	.91	.58	.56	.67	.63
Three or Four					
Total	10.69	10.88	11.35	11.30	11.11
JTW: HBW	2.03	2.11	2.22	2.05	2.13
JTW: HBNW	.65	.79	.79	.69	.76
JTW: NB	.45	.29	.38	.28	.34
JTW: WB	.70	.71	.86	.77	.78
JAW: NB	.09	.04	.06	.04	.05
JAW: WB	.58	.57	.80	.66	.67
Five or more					
Total	14.76	16.57	14.92	15.57	15.55
JTW: HBW	2.92	3.25	2.87	3.08	3.04
JTW: HBNW	.46	.80	.81	.63	.73
JTW: NB	.31	.29	.39	.22	.32
JTW: WB	.52	.87	.90	.57	.79
JAW: NB	.00	.11	.01	.03	.04
JAW: WB	.53	.46	.56	.49	.51
Total					
Total	9.01	9.50	9.24	9.26	9.30
JTW: HBW	1.88	1.91	2.01	1.88	1.94
JTW: HBNW	.55	.62	.60	.49	.58
JTW: NB	.33	.27	.27	.18	.27
JTW: WB	.61	.61	.67	.54	.62
JAW: NB	.04	.05	.03	.03	.04
JAW: WB	.60	.51	.61	.58	.57

Source: 1995 OMDP HIS CVF970307

Table 3.1-3
Trip Rates: Total and Non-Work-Related Purposes

Vehicles
Zero

	Household Income				Average
	<$20k	$20-40k	$40-75k	>$75k	
# Persons					
One					
Total	3.51	3.93	3.37	2.91	3.53
NWR: HBK12	.00	.00	.00	.00	.00
NWR: HBCol	.13	.03	.16	.08	.10
NWR: HBShp	.39	1.04	.43	.40	.64
NWR: HBOth	.77	1.19	1.09	.95	1.06
NWR: NHB	1.34	.93	.54	.32	.76
Two					
Total	4.45	5.50	3.83	5.69	4.88
NWR: HBK12	.18	.23	.06	.32	.19
NWR: HBCol	.00	.23	.04	.32	.16
NWR: HBShp	.47	1.15	.87	.00	.80
NWR: HBOth	.75	1.33	.38	2.23	1.11
NWR: NHB	.41	.86	.45	.64	.64
Three or Four					
Total	7.75	8.28	7.55	5.27	7.47
NWR: HBK12	.67	1.05	1.16	.87	1.01
NWR: HBCol	.00	.31	.02	.00	.10
NWR: HBShp	2.13	.95	1.49	1.00	1.35
NWR: HBOth	2.51	3.82	2.31	.61	2.56
NWR: NHB	2.31	.46	1.51	1.08	1.25
Five or more					
Total	8.06	4.00	9.45	10.61	9.49
NWR: HBK12	2.28	2.00	1.61	4.01	2.77
NWR: HBCol	.00	.00	.00	.00	.00
NWR: HBShp	1.01	.00	1.72	.56	1.04
NWR: HBOth	3.23	.00	1.86	4.36	3.23
NWR: NHB	1.01	.00	2.39	.56	1.25
Total					
Total	4.92	5.00	4.51	5.17	4.85
NWR: HBK12	.42	.21	.30	.83	.37
NWR: HBCol	.07	.13	.10	.12	.11
NWR: HBShp	.75	1.06	.79	.40	.81
NWR: HBOth	1.33	1.58	1.17	1.78	1.43
NWR: NHB	1.24	.84	.79	.54	.83

Source: 1995 OMDP HIS CVF970307

Table 3.1-3 (con't)
Trip Rates: Total and Non-Work-Related Purposes

Vehicles
One

	Household Income				Average
	<$20k	$20-40k	$40-75k	>$75k	
# Persons					
One					
Total	3.90	4.19	4.02	3.80	4.01
NWR: HBK12	.00	.00	.00	.02	.00
NWR: HBCol	.06	.13	.12	.05	.10
NWR: HBShp	.29	.27	.36	.52	.35
NWR: HBOth	.97	1.07	.84	.84	.93
NWR: NHB	.74	.76	.67	.79	.73
Two					
Total	7.07	7.24	6.61	7.16	6.99
NWR: HBK12	.11	.16	.15	.26	.16
NWR: HBCol	.00	.21	.18	.03	.15
NWR: HBShp	.76	1.28	.62	1.22	.98
NWR: HBOth	1.96	2.00	1.81	1.93	1.92
NWR: NHB	.78	1.55	1.38	1.04	1.31
Three or Four					
Total	8.56	8.72	9.50	11.65	9.57
NWR: HBK12	.62	1.02	.96	.78	.91
NWR: HBCol	.56	.23	.10	.34	.25
NWR: HBShp	1.18	.73	1.36	1.23	1.11
NWR: HBOth	2.28	2.66	2.68	3.67	2.82
NWR: NHB	1.03	1.56	1.67	2.09	1.64
Five or more					
Total	10.03	15.31	16.59	14.58	14.94
NWR: HBK12	1.67	2.51	3.11	4.55	2.85
NWR: HBCol	.28	.00	.12	.22	.11
NWR: HBShp	.73	.56	1.87	2.50	1.32
NWR: HBOth	2.84	5.73	5.82	1.61	4.86
NWR: NHB	1.55	3.16	2.34	1.27	2.38
Total					
Total	6.65	7.54	7.62	7.97	7.52
NWR: HBK12	.36	.56	.63	.61	.57
NWR: HBCol	.18	.17	.13	.14	.16
NWR: HBShp	.69	.79	.87	1.09	.86
NWR: HBOth	1.79	2.27	2.16	2.11	2.14
NWR: NHB	.91	1.49	1.34	1.29	1.32

Source: 1995 OMDP HIS CVF970307

Table 3.1-3 (con't)
Trip Rates: Total and Non-Work-Related Purposes

Vehicles
Two or more

	Household Income				Average
	<$20k	$20-40k	$40-75k	>$75k	
# Persons					
One					
Total	3.44	4.30	4.37	4.98	4.21
NWR: HBK12	.09	.00	.11	.00	.06
NWR: HBCol	.24	.04	.37	.00	.21
NWR: HBShp	.26	.39	.39	.13	.34
NWR: HBOth	.26	.65	.72	1.08	.63
NWR: NHB	.09	.79	.73	.18	.56
Two					
Total	8.13	7.62	6.90	7.11	7.33
NWR: HBK12	.10	.05	.02	.09	.05
NWR: HBCol	.02	.09	.04	.26	.09
NWR: HBShp	.58	.62	.77	.84	.71
NWR: HBOth	1.92	1.92	1.57	1.90	1.78
NWR: NHB	.77	1.21	1.01	1.70	1.16
Three or Four					
Total	11.78	11.85	12.26	11.49	11.95
NWR: HBK12	.84	.90	.95	.93	.92
NWR: HBCol	.17	.26	.13	.30	.21
NWR: HBShp	1.11	.90	.90	.92	.93
NWR: HBOth	3.35	3.13	2.91	3.22	3.08
NWR: NHB	2.03	2.26	2.01	1.89	2.08
Five or more					
Total	17.07	16.94	14.65	16.61	16.06
NWR: HBK12	1.82	1.77	1.93	2.35	1.92
NWR: HBCol	.24	.19	.17	.56	.24
NWR: HBShp	1.78	1.59	1.30	1.98	1.56
NWR: HBOth	5.91	4.89	3.58	4.94	4.55
NWR: NHB	2.18	3.02	2.12	2.33	2.48
Total					
Total	11.78	11.82	11.20	11.21	11.49
NWR: HBK12	.85	.87	.91	.97	.90
NWR: HBCol	.15	.19	.12	.34	.18
NWR: HBShp	1.10	.99	.94	1.11	1.00
NWR: HBOth	3.48	3.19	2.66	3.17	3.02
NWR: NHB	1.65	2.14	1.74	1.91	1.89

Source: 1995 OMDP HIS CVF970307

Table 3.1-3 (con't)
Trip Rates: Total and Non-Work-Related Purposes
Total

	Household Income				Average
	<$20k	$20-40k	$40-75k	>$75k	
# Persons					
One					
Total	3.74	4.10	3.84	3.61	3.88
NWR: HBK12	.01	.00	.01	.01	.01
NWR: HBCol	.10	.09	.15	.06	.11
NWR: HBShp	.32	.54	.38	.47	.44
NWR: HBOth	.85	1.09	.91	.88	.95
NWR: NHB	.85	.82	.63	.64	.73
Two					
Total	7.33	7.22	6.52	7.00	6.95
NWR: HBK12	.11	.11	.08	.18	.11
NWR: HBCol	.01	.16	.10	.17	.12
NWR: HBShp	.65	.97	.72	.93	.83
NWR: HBOth	1.83	1.89	1.57	1.94	1.78
NWR: NHB	.74	1.32	1.11	1.31	1.17
Three or Four					
Total	10.69	10.88	11.35	11.30	11.11
NWR: HBK12	.77	.94	.96	.88	.92
NWR: HBCol	.27	.25	.12	.30	.21
NWR: HBShp	1.19	.86	1.04	1.02	1.00
NWR: HBOth	3.01	3.04	2.83	3.27	2.99
NWR: NHB	1.78	2.00	1.90	1.93	1.92
Five or more					
Total	14.76	16.57	14.92	15.57	15.55
NWR: HBK12	1.82	1.93	2.19	2.92	2.15
NWR: HBCol	.23	.15	.15	.43	.20
NWR: HBShp	1.48	1.37	1.45	1.90	1.49
NWR: HBOth	5.00	5.07	4.03	4.30	4.56
NWR: NHB	1.95	3.05	2.18	1.94	2.41
Total					
Total	9.01	9.50	9.24	9.26	9.30
NWR: HBK12	.61	.68	.74	.81	.72
NWR: HBCol	.15	.18	.12	.24	.16
NWR: HBShp	.90	.92	.90	1.03	.93
NWR: HBOth	2.58	2.68	2.33	2.60	2.52
NWR: NHB	1.32	1.76	1.50	1.51	1.57

Source: 1995 OMDP HIS CVF970307

Table 3.1-4: Trip Attractors by Purpose

Trip Purpose	Attractor: Employees Total	Employees Retail	Students Pri/Sec	Students College	Hlds Total
JTW: HBW	X				
JTW: HBNW	x	X	X	X	X
JTW: WB	X				
JTW: NB	x	X	X	X	X
JAW: WB	X	X			
JAW: NB	X	X			
NWR: HBK12			X		
NWR: HBCol				x	
NWR: HBShp		X			
NWR: HBOth	x	X	X	x	X
NWR: NHB	x	X	X	x	X

Note: An "X" indicates that rates are computed by area type, while an "x" indicates that attraction rates are not area-type specific.

Area types are defined as a function of the employment density in the zone and the population density in the zone. An exception is that all military zones are defined as having a "Military" area type regardless of the zonal densities. The employment and population density categories that define each area type are as follows:

Area-Type Definitions Based on Population and Employment Densities

Employment Density (Jobs per Square Mile)	≤93	94–1,615	1,616–22,630	22,631–78,500	>78,500
Population Density (Population per Square Mile)					
≤192	Rural	Suburb	Urban	Core	CBD
193–4,975	Suburb	Suburb	Urban	Core	CBD
4,976–24,000	Urban	Urban	Urban	Core	CBD
>24,000	Core	Core	Core	Core	CBD

Table 3.1-5
Attraction Rates for Resident Travel

	Trips per Attractor					Trips per Retail Employment by Area Type						Trips per Total Employment by Area Type					
	Employment		Students		Hlds												
Purpose	Total	Retail	Pri/Sec	College	Total	CBD	Core	Urban	Suburb	Rural	Gov't	CBD	Core	Urban	Suburb	Rural	Gov't
JTW: HBW	1.15											1.32	1.06	1.13	1.04	1.16	1.34
JTW: HBNW	0.12	0.58	0.22	0.00	0.06	0.34	0.53	0.79	0.37	0.27	0.18						
JTW: WB	0.34											0.39	0.37	0.34	0.32	0.20	0.27
JTW: NB	0.06	0.27	0.06	0.00	0.03	0.10	0.28	0.34	0.16	0.11	0.26						
JAW: WB	0.20	0.72				1.96	0.71	0.61	0.31	0.53	1.04	0.25	0.21	0.22	0.16	0.09	0.18
JAW: NB	0.01	0.07				0.19	0.07	0.07	0.02	0.12	0.07	0.01	0.01	0.01	0.01	0.01	0.01
NWR: HBSchl			1.26														
NWR: HBUniv				0.89													
NWR: HBShop		2.50				1.07	1.70	3.73	3.07	2.27	2.25						
NWR: HBOthr	0.86	0.88	0.76	0.00	0.33	0.49	0.64	1.29	0.63	0.70	0.57						
NWR: NHB	0.28	1.83	0.21	0.14	0.16	0.62	1.33	2.64	1.73	0.97	1.51						
Total	3.02	6.84	2.51	1.04	0.58	4.76	5.25	9.47	6.29	4.98	5.87						

	Unweighted Trips by Attractor					Weighted Trips by Attractor (,000)				
	Employment		Students		Hlds	Employment		Students		Hlds
Purpose	Total	Retail	Pri/Sec	College	Total	Total	Retail	Pri/Sec	College	Total
JTW: HBW	6,256					513				
JTW: HBNW	749	588	437		223	55	44	33		17
JTW: WB	2,006					151				
JTW: NB	349	277	114	3	115	25	20	9	<1	10
JAW: WB	1,331	732				91	54			
JAW: NB	66	71				4	5			
NWR: HBSchl			2,295					190		
NWR: HBUniv				485					43	
NWR: HBShop		2,368					189			
NWR: HBOthr	4,929	893	1,311		1,118	386	67	114		93
NWR: NHB	1,644	1,771	417	76	525	127	138	31	8	45
Total	17,330	6,700	4,574	564	1,981	1,352	517	377	51	165

Notes: All trips and employment for persons not living in group quarters. Total employment factored to match HIS jobs by Area Type.
Sources: 1995 OMDP HIS, 1990 OMPO Zonal Data, 1990 U.S. Census

Regionwide Balancing and Zonal Allocation

The production and attraction submodels have now produced trip-ends by zone for each purpose. However, as each of these submodels has acted independently, nothing guarantees that the island-wide total productions equals the total attractions. Therefore, a balancing process occurs at this point to ensure these island-wide totals equate. Depending on the trip purpose, the total productions may be factored to match the total attractions or vice-versa. Table 3.1-6 shows the balance control for each trip purpose. The work-based journey-to-work purposes (HBW and WB) balance to attractions to ensure that the correct number of workers arrive at their workplaces. All other purposes balance to productions.

For non-home-based trip purposes, household locations provide no information about trip-productions like they do for home-based trip purposes. Therefore, after balancing to regionwide total productions, the zone-level productions are set equal to the zone-level attractions. This standard convention for non-home-based purposes allocates productions consistently with the information provided by attraction locations.

The journey-to-work work-based (JTW-WB) trip purposes presents an exception to this rule. After balancing to regionwide attractions, zone-level productions equal JTW-HBNW attractions minus JTW-NB productions. This ensures that all intermediate stop zones on journeys to work have appropriate productions and attractions.

Table 3.1-6: Balance Control by Trip Purpose

	Balance Control	
Purpose	**Productions**	**Attractions**
JTW: HBW		X
JTW: HBNW	X	
JTW: WB		X
JTW: NB	X	
JAW: WB	X	
JAW: NB	X	
NWR: HBK12	X	
NWR: HBCol	X	
NWR: HBShp	X	
NWR: HBOth	X	
NWR: NHB	X	

3.2 Development

The rates for each of eleven trip purposes have been developed from the 1995 Household Interview Survey (HIS) conducted for this project. This stratification uses an imputed income class for households not reporting income, where the imputed class is a function of the household's size and composition and its home zone's average income. The models apply the trip production rates as calculated directly from the HIS and presented in table 3.1-2 and 3.1-3. In general the rates increase with increasing household size, income, and vehicle ownership, as expected.

Table 3.1-5 presents attraction rates by purpose derived from the HIS, as well as raw and expanded trip counts to help identify low-sample cells as discussed above. Because the survey data provide full detail on every trip made, the specific attractor type was easily identified and categorized. The island-wide rates were developed by dividing the total number of trips with that attractor by the total number of attractors of that type. For area-type specific rates, the trips and attractors are summed for each area-type independently.

Attractor totals by zone have been obtained from: employment from the DLIR 1994 unemployment data; households from the 1990 U.S. Census; and students from OMDP Project Team summaries of 1995 enrollment by school geocoded to zone.

4. Trip Distribution

The Trip Distribution model estimates the number of trips, by purpose, between each pair of zones. This step creates all zone-to-zone trip tables for Trip-Based models, thereby establishing the travel patterns that are considered by the later stages of the model set (including mode choice, time-of-day choice, and network assignment). The Trip Distribution model is stratified by the 11 trip purposes considered in the Trip Generation model and creates a trip table for each purpose by linking trip-ends produced in Trip Generation step. The trip tables produced by the Trip Distribution model include travel by all modes and at all times of day.

4.1. Description

The Trip Distribution models use a two-stage process to link trip productions to trip attractions and produce zone-to-zone trip tables. The first step applies a logit-form destination choice model that distributes the productions for each zone across the attractions estimated for all zones. The trip table produced by this step is "singly constrained" in that the summation of trips across each row necessarily matches the productions estimated for each production-zone; however, the summation of trips down each column does not necessarily match the attractions estimated for each attraction-zone. To "doubly constrain" the trip table, the second step in the model applies a matrix-balancing method – known variously as Iterative Proportional Fitting (IPF) or Fratar – to ensure that both the row-sums equal the estimated productions and the column-sums equal the estimated attractions. The matrix-balancing step treats the logit-estimated trip table as a seed matrix and treats the trip-end estimates from the Trip Generation model as marginal totals that must be matched by the trip table. The resulting trip table for each trip purpose therefore matches both the productions and the attraction estimated for each zone in Trip Generation. The general structure of the Trip Distribution model is the same for each trip purpose. Table 4.1-1 summarizes the key features of the Trip Distribution model.

<u>Step 1: Multinomial Logit</u>

The logit model used in the first step of the model considers the trips produced from one zone at a time. The model estimates the share of the trips produced in that zone that will be attracted to each candidate attraction zones (including intra-zonal travel within the production zone). Consequently, the logit model considers a choice set that includes all zones:

$$(1) \qquad T_{ij} = P_i * \frac{\exp[f(IMP_{ij}) + \ln(A_j)]K_{ij}}{\sum_z \exp[f(IMP_{iz}) + \ln(A_z)]K_{iz}}$$

where	T_{ij}	is the number of trips produced from zone i and attracted to zone j;
	P_i	is the number of trip-productions in zone i;
	$f(IMP_{ij})$	is the impedance function for travel from zone i to zone j (see equation 2);
	$\ln(A_j)$	is the natural logarithm of the number of trip-attractions in zone j;
	K_{ij}	is a K-factor applied to trips estimated between i and j; and
	Σ_k	is the sum over all candidate attraction zones k.

Table 4.1-1

Key Features of the Trip Distribution Model

Inputs

- Outputs from the trip generation model: productions and attractions by purpose in each zone
- Zone-to-zone highway time: peak period for use with purposes describing travel to/from work; off-peak for use with all other trip purposes

Outputs

- Zone-to-zone 24-hour person trip tables stratified by purpose (and if necessary by vehicle ownership)

Method

- Multinomial logit model that considers all zones as alternative destinations
- Size characteristics of each destination zone equal to the number of attractions predicted by the Trip Generation model
- Travel impedance terms in the utility expression: highway travel time and highway travel time squared
- Parameters on impedance terms developed from Oahu diary data and coded networks
  - "Doubly constrained" so that the sum of Tij across all i-zones equals attractions predicted by the Trip Generation model for each j-zone

Equation 1 identifies the information needed for application of the Trip Distribution model: productions P and attractions A for each zone, plus a matrix of impedances between zones and a matrix of K-factors if necessary.

The utility of each attraction zone in the destination-choice model depends on its size (represented by number of attractions estimated for each zone) and its separation (travel impedance) from the production zone. The function g() in Equation 1 must be the natural log operator (ln) to ensure that the shares estimated by the model are independent of the level of spatial aggregation employed. That is, the function must be defined so that the aggregation of two zones into a single larger zone does change the total share predicted for the aggregated zone. This outcome occurs only when the function g() is defined as the natural log of the number of trip-attractions. In contrast, a variety of forms can be used for the function f() to describe the effect of spatial separation on trip-making between zones. For the Trip-Based models, the function form is:

(2) $$f(IMP_{ij}) = p_1 * TT_{ij} + p_2 * TT_{ij}^2$$

TT_{ij}	is the highway travel time from zone i to zone j;
p_1	is the coefficient on highway travel time;
p_2	is the coefficient on highway travel time squared;

Consequently, the information required by the Trip Distribution model includes only the zone-to-zone highway travel times derived from the highway network and the zone-specific trip productions and attractions estimated by the Trip Generation model. The application uses peak-period highway times for all journey-to-work trip-purposes and for both home-based school trip purposes. It uses off-peak highway times for the two journey-at-work purposes, the two remaining home-based purposes, and the non-home-based trip-purpose.

<u>Step 2: Matrix Balancing</u>

The second step in the Trip Distribution model – matrix balancing – simply ensures that for the final trip table the sum of trips to each attraction zone equals the input number of attractions, and the same for productions. The balancing step alternately factors the rows and columns to apply these constraints. Iterations continue until the row-sums match the productions and the column-sums match the attractions within a user-specified tolerance. This approach is mathematically identical to an approach that factors the attractiveness of each attraction zone after each iteration, based on a comparison of the trip-attractions estimated by the Trip Generation model and the column-sum of the trip table produced in the iteration. The factor for each attraction zone is computed as the ratio of the trip-attractions to the column sum for that zone. Consequently, in the next iteration, attraction zones that received too many trips would be less attractive and attraction zones that received too few trips would be more attractive. Iterations would proceed to closure on the column sums. However, mathematically identical matrix-balancing method is computationally more efficient because it avoids recalculation of the exponential terms in the logit expression. The application software therefore uses the matrix-balancing approach to minimize processing time.

4.2. Development

The functional form of the trip distribution model – multinomial logit with time and time-squared as the variables describing travel impedance – has been borrowed from the travel forecasting models currently used in Portland, Oregon. Calibration of the Trip Distribution model for Oahu required three steps:

1. the selection of a specific measure of travel impedance for the spatial-separation term(s) in the utility expression;

2. estimation of the parameter(s) on the travel impedance variables for each trip purpose, using travel patterns and travel conditions currently observed on Oahu; and

3. an analysis to determine the usefulness of stratification of the journey-to-work-related models by some socio-economic attribute of workers.

The resulting models are almost entirely based on current conditions on Oahu. Only the form of the spatial-separation function has been transferred from elsewhere.

<u>Measure of Travel Impedance</u>

The logit formula of Equation 1 allocates productions from each zone across all attraction zones as a function of each attraction-zone's total attractions and the travel impedance between the zones. Candidates for the measure of travel impedance include highway travel time and multi-modal (composite) impedance. Tests were done for the journey-to-work-related purposes using a common measure of multi-modal impedance – the LogSum formulation computed as the natural logarithm of the denominator of the mode choice model to capture the contributions to accessibility of all attributes of all modes. The tests did not yield a result consistent with utility theory in that the best-fit coefficients estimated for Oahu were in the range of 1.5 to 1.8 and theory requires that the LogSum coefficient should be between 0.0 and 1.0.

Consideration was also given to using transit travel time (instead of highway) for households not owning vehicles. In other settings, this allows the distribution of these households' trips to follow the availability of transit service. However, many households not owning vehicles still take trips as passengers, making the distribution of their destinations by transit alone incorrect. Moreover, on Oahu, transit service reaches nearly all destinations. Thus, the use of transit or highway impedances for zero-vehicle households does not critically affect their distribution patterns. For simplicity, the model uses highway travel time for all trip purposes and vehicle-ownership classes.

<u>Parameter Estimates</u>

The purpose-specific trip tables derived from the Oahu diary survey provide information about the real distribution of trips on the island. The "observed" information in these tables can be summarized in two useful ways: as district-to-district trip tables, and as trip-length frequency distributions (TLFDs). Appendix 4-A summarizes the observed district-level trip table and TLF for each trip purpose. For calibration purposes, zone-specific row- and column-totals from these observed trip tables provide the observed numbers of productions and attractions in each zone. A matrix of highway travel times, derived from the coded highway network (for both peak and off-peak travel) represent congested conditions for journey-to-work-related trip purposes, and free-flow conditions for other purposes.

Calibration of the travel-impedance parameters for each trip purpose relied on comparisons of the estimated and observed district-level trip tables and the TLFDs. Because only two parameters require estimation and because of the computational speed of the custom-written Fortran application software, it has been possible to use a "calibration by enumeration" strategy for the Trip Distribution models. The software applies up to 100 combinations of trial values of p_1 and p_2 and computes goodness-of-fit statistics against both the observed district-level trip table and the TLFD. Two passes of the calibration have been used for each trip purpose. An initial pass using relatively coarse increments of parameter values established the general range of the best-fit values for both parameters. A second pass with relatively fine increments of parameter values established the specific pair of best-fit parameter values. The TD program[1] contains an automated calibration feature that facilitates this calibration method.

After calibration, some estimated district-level interchanges differ from the observed values. To ensure that the final model fits the observed data as well as possible, district-level K-factors wereapplied. The Fortran program computes K-factors automatically as needed, according to user-specified absolute- and relative-difference criteria. Analysis of the distribution models for work travel on Oahu has demonstrated that some employment patterns are unlikely to be explained fully by any classification scheme. In particular, employment in the hotel industry appears to show the residual effects of the timing of immigration to the islands of different ethnic groups. Consequently, larger-than-expected numbers of workers travel to Waikiki (in particular) from residential areas with concentrations of ethnic groups that have historically been heavily represented among hotel workers. Conversely, fewer-than-expected workers travel to Waikiki from residential areas with concentrations of ethnic groups that have historically been under-represented among hotel workers. Tests of workplace-choice models examined various market-segmentation variables including household income, individual workers earnings, occupation/industry, and gender. All of these segmentation strategies reduced the residuals in the predictions of work travel to Waikiki, but only marginally. Further, the remaining residuals in the Waikiki employment market were clearly related to ethnicity. The conclusions drawn from these tests were that:

- none of the tested segmentation strategies would explain fully the home-work linkages for employees in the hotel industry;
- segmentation by ethnicity might prove to be a more effective strategy, but would not be useful given the longer-term changes in employment patterns among ethnic groups; and
- district-level K-factors would be used for the limited number of home-work travel markets that are affected by employment patterns in the hotel industry.

[1] The TD program is documented in the User's Guide to Model Application in Chapter 2. The "calib" option invokes this self-calibration method.

The decision to use a limited number of K-factors was made with the provision that the application software provide to the user a straightforward mechanism to reduce or eliminate the effects of the K-factors in future forecasts. This feature will permit testing of assumptions that the effects of historic employment patterns will diminish or disappear over time.

Table 4.2-1 presents final calibrated parameters for each of the trip purposes with some purposes stratified by vehicle ownership. For each purpose, the tables in Appendix 4-A present the estimated and observed district-level trip tables, their absolute and relative differences, and a plot of the estimated and observed TLF distributions.

Table 4.2-2 presents the observed and estimated trip lengths by all of the purposes used. For purposes that are stratified by vehicle ownership, the trip lengths for all vehicle ownership classes together are presented as well. As can be seen, the estimated trip lengths are close to the observed trip lengths for all purposes and vehicle ownership classes, with the largest difference only being 3 percent and most differences under 2 percent. Estimated versus observed differences of 5 percent or less are normally acceptable.

Stratification by Socio-Economic Characteristics (Vehicle Ownership)

If identifiable segments of travelers behave differently, the Trip Distribution model should be applied to these segments separately. This rationale leads to the use of a different Trip Distribution model for each trip purpose, and could also lead to different models for individual socioeconomic segments of the population. Segmentation of trips by some socioeconomic characteristic of trip-makers would serve two purposes. First, the Trip Distribution model would be more accurate if travelers in different segments do, in fact, behave differently. Second, the mode-choice model requires as input trip tables stratified by socioeconomic class (household vehicle-ownership) because trip-makers certainly make mode-choice decisions differently based on their vehicle ownership class, at least. For all home-based purposes (with the exception of home-based school and journey-to-work home-based non-work) the calibration is performed by vehicle ownership class.

Given the decision to segment the travel markets but not use a composite impedance measure, calibration of a single set of impedance parameters for each purpose (stratified by vehicle ownership if necessary) and K-factors for each purpose fully defines the trip distribution model.

The procedure for calibrating the Trip Distribution model by vehicle ownership classes is identical to the calibration by trip purposes aggregated over vehicle ownership classes with the exception of an additional step. The Trip Distribution parameters and K-factors may allow the Trip Distribution model to estimate trips that match the observed for that particular vehicle ownership class; however, when summed over all vehicle ownership classes, the estimated trip matrix may not match the observed. Therefore, K-factors for trip tables summed over all vehicle ownership classes are computed and then interacted with the K-factors for each vehicle ownership class. The resulting K-factor table not only adjusts the estimated trips so that the trips by vehicle ownership class match the observed but also adjusts the estimated trips so that the trips summed over all vehicle ownership classes match the observed.

Table 4.2-1: Calibrated Parameters for Travel Impedance

Purpose	p_1(time)	p_2(time^2)
Journey-to-Work Home-Based Work (0 vehicles)	-0.14	0.00064
Journey-to-Work Home-Based Work (1 vehicle)	-0.17	0.00136
Journey-to-Work Home-Based Work (2+ vehicles)	-0.16	0.00133
Journey-to-Work Home-Based Non-Work	-0.298	0.00316
Journey-to-Work Work-Based	-0.16	0.00105
Journey-at-Work Work-Based	-0.38	0.0054
Journey-to-Work Non-Home-Based, Non-Work-Based	-0.26	0.00281
Journey-at-Work Non-Work-Based	-0.53	0.00449
Non-Work-Related Home Based Other (0 vehicles)	-0.65	0.0159
Non-Work-Related Home Based Other (1 vehicle)	-0.38	0.00445
Non-Work-Related Home Based Other (2+ vehicles)	-0.34	0.00286
Non-Work-Related Non-Home-Based	-0.54	0.01145
Non-Work-Related Home-Based Shopping (0 vehicles)	-1.15	0.0301
Non-Work-Related Home-Based Shopping (1 vehicle)	-0.45	0.0058
Non-Work-Related Home-Based Shopping (2+ vehicles)	-0.37	0.00224
Non-Work-Related Home-Based K-12 School	-0.44	0.00514
Non-Work-Related Home-Based College (0 vehicles)	-0.27	0.00300
Non-Work-Related Home-Based College (1 vehicle)	-0.14	0.00131
Non-Work-Related Home-Based College (2+ vehicles)	-0.07	0.00015

Table 4.2-2: Average Observed and Estimated Trip Lengths by Purpose

Purpose	Observed Trip Length (min)	Estimated Trip Length (min)	Absolute Difference from Observed	Relative Difference from Observed
Journey-to-Work Home-Based Work (0 vehicles)	11.61	11.83	0.22	1.9%
Journey-to-Work Home-Based Work (1 vehicle)	16.79	16.72	-0.06	-0.4%
Journey-to-Work Home-Based Work (2+ vehicles)	21.22	21.26	0.04	0.2%
Journey-to-Work Home-Based Work (All vehicles)	19.38	19.40	0.02	0.1%
Journey-to-Work Home-Based Non-Work	14.33	14.34	0.01	0.1%
Journey-to-Work Work-Based	13.62	13.58	-0.04	-0.3%
Journey-at-Work Work-Based	5.78	5.78	0.00	0.0%
Journey-to-Work Non-Home-Based, Non-Work-Based	10.81	10.78	-0.03	-0.3%
Journey-at-Work Non-Work-Based	4.78	4.80	0.02	0.4%
Non-Work-Related Home Based Other (0 vehicles)	6.40	6.41	0.01	0.1%
Non-Work-Related Home Based Other (1 vehicle)	7.18	7.22	0.04	0.6%
Non-Work-Related Home Based Other (2+ vehicles)	7.57	7.60	0.03	0.4%
Non-Work-Related Home Based Other (All vehicles)	7.38	7.41	0.03	0.4%
Non-Work-Related Non-Home-Based	6.43	6.45	0.02	0.2%
Non-Work-Related Home-Based Shopping (0 vehicles)	4.34	4.32	-0.02	-0.4%
Non-Work-Related Home-Based Shopping (1 vehicle)	7.51	7.23	0.08	1.1%
Non-Work-Related Home-Based Shopping (2+ vehicles)	6.60	6.62	0.02	0.3%
Non-Work-Related Home-Based Shopping (All vehicles)	6.58	6.62	0.04	0.6%
Non-Work-Related Home-Based K-12 School	9.75	9.77	0.02	0.2%
Non-Work-Related Home-Based College (0 vehicles)	5.89	5.99	0.09	1.6%
Non-Work-Related Home-Based College (1 vehicle)	15.42	15.68	0.25	1.6%
Non-Work-Related Home-Based College (2+ vehicles)	19.43	19.25	-0.19	-1.0%
Non-Work-Related Home-Based College (All vehicles)	17.06	17.04	-0.01	-0.1%

Appendix 4-A

Average Trip Lengths Resulting from Trip Distribution

Purpose	Observed Trip Length from HIS (min)	Estimated Trip Length from Calibration (min)	Abs Diff from Obs	Rel Diff from Obs	Estimated Trip Length using Ps and As (min)	Abs Diff from Obs	Rel Diff from Obs
Journey-to-Work Home-Based Work (0 vehicles)	11.61	11.83	0.22	1.9%	14.44	2.83	24.4%
Journey-to-Work Home-Based Work (1 vehicle)	16.79	16.72	-0.06	-0.4%	18.21	1.43	8.5%
Journey-to-Work Home-Based Work (2+ vehicles)	21.22	21.26	0.04	0.2%	21.99	0.77	3.6%
Journey-to-Work Home-Based Work (All vehicles)	19.38	19.40	0.02	0.1%	20.49	1.11	5.7%
Journey-to-Work Home-Based Non-Work	14.33	14.34	0.01	0.1%	14.34	0.02	0.1%
Journey-to-Work Work-Based	13.62	13.58	-0.04	-0.3%	14.50	0.88	6.5%
Journey-at-Work Work-Based	5.78	5.78	0.00	0.0%	5.49	-0.28	-4.9%
Journey-to-Work Non-Based	10.81	10.78	-0.03	-0.3%	11.51	0.70	6.5%
Journey-at-Work Non-Based	4.78	4.80	0.02	0.4%	3.66	-1.12	-23.5%
Non-Work-Related Home Based Other (0 vehicles)	6.40	6.41	0.01	0.1%	9.04	2.63	41.2%
Non-Work-Related Home Based Other (1 vehicle)	7.18	7.22	0.04	0.6%	8.52	1.34	18.6%
Non-Work-Related Home Based Other (2+ vehicles)	7.57	7.60	0.03	0.4%	9.32	1.74	23.0%
Non-Work-Related Home Based Other (All vehicles)	7.38	7.41	0.03	0.4%	9.05	1.68	22.7%
Non-Work-Related Non-Home-Based	6.43	6.45	0.02	0.2%	6.68	0.25	3.9%
Non-Work-Related Home-Based Shopping (0 vehicles)	4.34	4.32	-0.02	-0.4%	5.29	0.96	22.1%
Non-Work-Related Home-Based Shopping (1 vehicle)	7.15	7.23	0.08	1.1%	8.20	1.05	14.8%
Non-Work-Related Home-Based Shopping (2+ vehicles)	6.60	6.62	0.02	0.3%	8.17	1.57	23.8%
Non-Work-Related Home-Based Shopping (All vehicles)	6.58	6.62	0.04	0.6%	7.90	1.32	20.0%
Non-Work-Related Home-Based School	9.75	9.77	0.02	0.2%	10.13	0.38	3.9%
Non-Work-Related Home-Based College (0 vehicles)	5.89	5.99	0.09	1.6%	15.73	9.84	166.9%
Non-Work-Related Home-Based College (1 vehicle)	15.42	15.68	0.25	1.6%	23.44	8.02	52.0%
Non-Work-Related Home-Based College (2+ vehicles)	19.43	19.25	-0.19	-1.0%	24.91	5.48	28.2%
Non-Work-Related Home-Based College (All vehicles)	17.06	17.04	-0.01	-0.1%	23.86	6.80	39.9%

Journey-to-Work Home-Based Work All-Veh
Estimated Trips

Production District	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
1 Downtown	3837	540	448	590	623	76	83	146	449	122	896	499	190	151	56	39	23	4	6	8	133	45	59	9023
2 Kakaako	1223	403	288	507	466	55	42	114	120	40	247	169	53	57	20	17	13	2	2	2	39	18	33	3930
3 Makiki	5422	1577	2101	2846	2886	347	356	956	1029	277	1596	1241	426	394	140	107	76	22	15	17	315	115	247	22508
4 McCully	4917	1477	1667	5360	3450	537	601	1240	675	219	1184	974	314	315	111	98	68	20	14	19	232	89	326	23907
5 Waikiki	4174	1351	1283	3303	5252	515	456	797	523	134	871	663	245	199	88	69	50	17	12	16	202	69	231	20520
6 Diamond Hd	3352	638	772	1457	2365	1048	617	985	369	164	816	768	197	248	92	90	71	28	7	17	152	78	349	14680
7 Kaimuki	3583	874	1113	1950	2348	968	1133	1428	563	270	1286	1234	303	415	145	166	120	43	21	30	246	123	458	18820
8 Manoa	2585	542	640	1120	971	260	261	906	278	146	649	624	149	215	72	87	64	26	13	17	115	65	150	9955
9 Nuuanu	6454	1168	904	1255	1056	245	196	420	1433	503	3131	1502	402	511	162	158	109	35	9	22	452	250	143	20520
10 Kalihi	4827	839	599	831	719	204	182	285	992	963	4257	2761	770	909	281	240	166	37	22	29	619	183	136	20851
11 Iwilei	3176	702	551	740	694	122	156	187	584	433	3187	2088	631	565	189	139	90	15	16	15	314	67	102	14763
12 Airport PH	1389	275	180	305	267	94	74	171	191	161	1308	6129	576	1189	2217	280	184	36	18	18	146	51	64	15323
13 Salt Lake	3191	775	549	897	810	275	219	478	599	517	2682	6860	3942	3472	963	829	525	103	43	53	451	161	191	28585
14 PC Aiea	4524	1032	697	1220	1001	392	340	648	630	595	5192	9973	2335	8707	4552	3296	2090	323	173	139	681	283	317	49140
15 Waipahu	3201	464	311	1721	3232	154	146	277	299	247	1741	3776	709	3322	5278	2728	2563	241	119	76	317	125	140	31187
16 Mililani	3487	835	551	1003	1033	316	251	507	498	377	2520	5335	942	3374	2498	22033	2367	460	715	242	714	378	335	50771
17 Ewa	2909	713	441	836	2127	259	207	414	411	339	2181	4456	726	3058	2950	3114	9742	2534	146	173	550	286	271	38843
18 Waianae	1267	334	235	437	578	140	103	229	196	119	695	2609	260	691	637	709	1342	5928	90	145	436	246	201	17627
19 NorthShore	768	212	142	269	343	90	66	140	118	79	429	789	160	424	387	1957	334	148	1607	344	266	148	125	9345
20 Koolauloa	545	139	102	189	277	67	43	100	87	51	285	465	107	190	140	243	180	101	206	3615	326	120	93	7671
21 Kaneohe	4855	1057	685	1095	971	269	224	409	959	751	2686	2926	692	1096	422	559	407	198	77	247	9626	2378	234	32823
22 Kailua	4665	931	632	1012	917	212	181	347	914	395	1514	1523	371	598	274	417	312	173	80	133	3990	6732	572	26895
23 E Honolulu	4091	1131	1140	1981	1930	954	757	1274	608	347	1603	1818	404	677	289	449	338	190	70	110	561	569	4195	25486
Totals	78442	18009	16031	30924	34316	7599	6694	12458	12525	7249	40956	59182	14904	30777	21963	37824	21234	10684	3481	5487	20883	12579	8972	513173

Journey-to-Work Home-Based Work All-Veh
Observed Trips

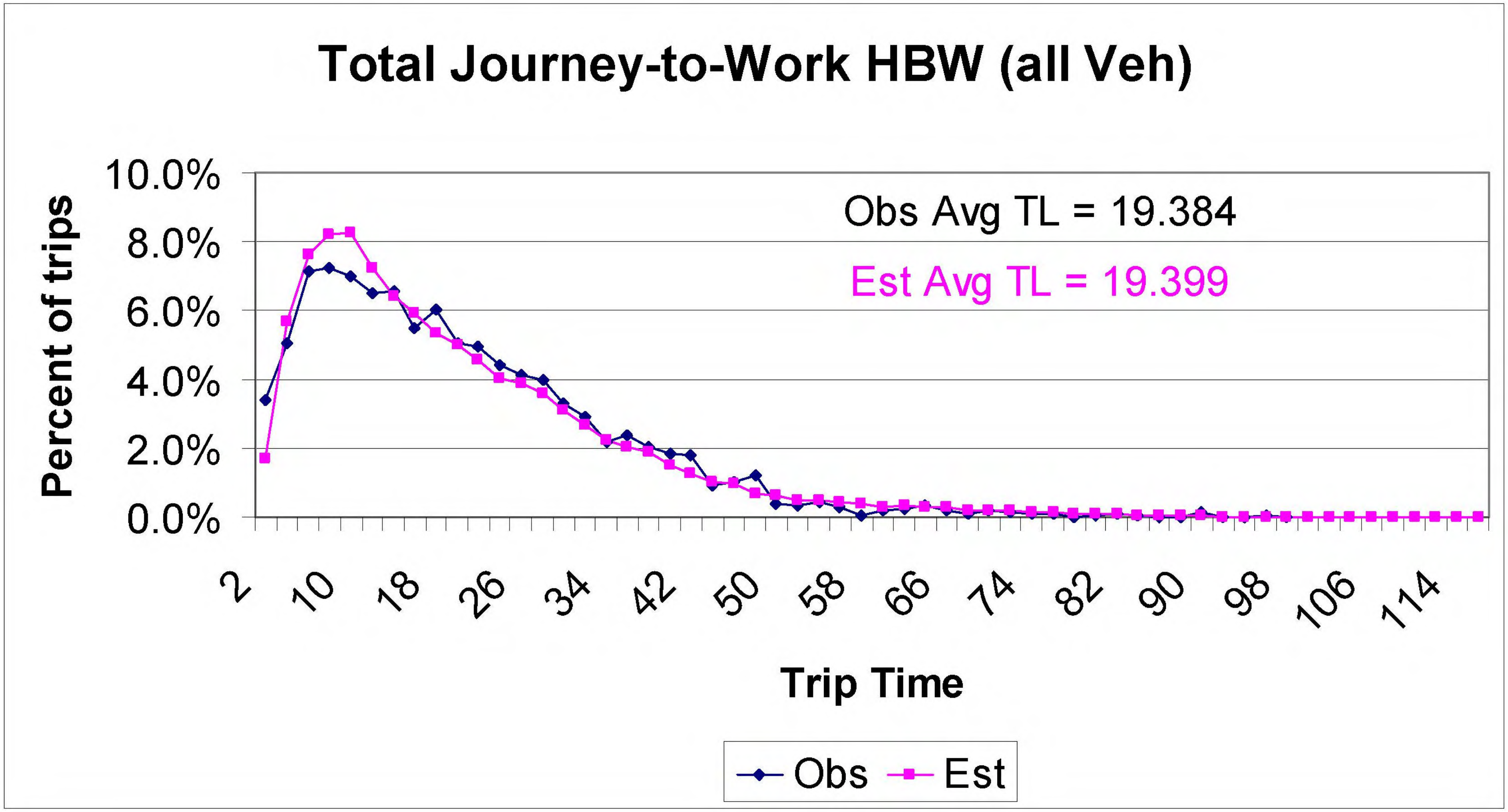
Production District	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
	Attraction District																							
1 Downtown	5014	161	377	373	1443	0	127	0	762	103	283	207	0	58	0	0	0	0	0	0	0	115	0	9023
2 Kakaako	959	354	0	199	1126	0	0	0	40	0	410	346	275	0	140	0	0	0	0	0	81	0	0	3930
3 Makiki	4704	1521	2491	2520	1507	513	0	1946	1170	227	1280	1413	702	378	226	322	212	0	0	0	139	155	1082	22508
4 McCully	4229	798	845	5378	3182	127	938	1401	258	101	1923	737	585	394	203	0	262	0	350	0	1160	189	847	23907
5 Waikiki	3871	837	1260	1796	4563	410	140	613	982	0	754	1475	458	453	278	0	677	0	0	0	969	0	984	20520
6 Diamond Hd	3876	976	766	1269	1362	1350	988	852	125	353	1072	699	51	379	0	41	170	61	0	109	0	0	181	14680
7 Kaimuki	4060	752	634	1869	2130	1493	1992	591	343	447	1822	638	0	728	0	288	145	171	0	0	104	173	440	18820
8 Manoa	2325	483	377	1715	772	38	0	1852	304	252	337	768	187	0	264	0	70	0	0	0	86	125	0	9955
9 Nuuanu	5735	1318	821	1175	1315	109	0	925	1984	502	3453	1220	0	516	302	19	414	62	0	0	196	413	41	20520
10 Kalihi	4268	1869	488	1262	2000	268	175	332	1155	958	4375	1845	0	788	0	83	554	69	0	0	256	81	25	20851
11 Iwilei	2923	895	416	1305	1373	0	0	0	259	0	3022	1491	1114	219	0	0	978	0	0	58	0	455	255	14763
12 Airport PH	1477	97	56	0	0	0	0	0	40	47	1002	8039	341	1596	2262	67	137	0	0	0	162	0	0	15323
13 Salt Lake	4128	624	1129	987	769	537	272	233	1220	207	2685	5352	4743	2489	1140	1367	160	0	0	0	148	395	0	28585
14 PC Aiea	6703	781	841	1949	859	659	180	204	843	759	5548	11596	1761	7212	4307	1968	1994	42	233	0	535	0	166	49140
15 Waipahu	3898	242	201	2237	3835	0	88	134	593	114	2001	4808	350	3989	4186	1930	1411	447	174	0	415	134	0	31187
16 Mililani	3261	965	523	1556	1112	331	433	174	64	99	2385	5350	1811	2927	2217	23309	1349	618	491	0	1582	0	214	50771
17 Ewa	3081	301	616	771	2264	8	0	186	1075	877	2611	4083	341	4825	2662	2527	9576	2745	0	0	294	0	0	38843
18 Waianae	215	253	367	771	571	285	0	0	225	130	490	2945	97	241	1182	1297	1662	6072	0	0	0	824	0	17627
19 NorthShore	77	199	163	250	173	57	0	120	0	150	398	869	16	408	854	2823	168	179	1885	408	0	148	0	9345
20 Koolauloa	663	0	0	0	134	0	0	0	0	0	167	151	134	267	54	199	592	227	152	4704	227	0	0	7671
21 Kaneohe	3661	1494	1687	842	1273	269	0	354	630	675	1970	2437	693	1645	901	717	0	0	0	1451	1021	2327	82	32823
22 Kailua	4493	1636	1009	960	788	272	97	637	323	517	1215	1502	1013	634	283	0	601	0	215	63	3555	6716	366	26895
23 E Honolulu	4865	1450	967	1745	1755	876	1273	1890	122	729	1736	1207	228	606	505	836	58	0	0	0	0	341	4297	25486
Totals	78486	18006	16034	30929	34306	7602	6703	12444	12517	7247	40939	59178	14900	30752	21966	37793	21190	10693	3500	5487	20930	12591	8980	513173

Journey-to-Work Home-Based Work All-Veh
Estimated Trips - Observed Trips

Production District	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
1 Downtown	-1177	379	71	217	-820	76	-44	146	-313	19	613	292	190	93	56	39	23	4	6	8	133	-70	59	0
2 Kakaako	264	49	288	308	-660	55	42	114	80	40	-163	-177	-222	57	-120	17	13	2	2	2	-42	18	33	0
3 Makiki	718	56	-390	326	1379	-166	356	-990	-141	50	316	-172	-276	16	-86	-215	-136	22	15	17	176	-40	-835	0
4 McCully	688	679	822	-18	268	410	-337	-161	417	118	-739	237	-271	-79	-92	98	-194	20	-336	19	-928	-100	-521	0
5 Waikiki	303	514	23	1507	689	105	316	184	-459	134	117	-812	-213	-254	-190	69	-627	17	12	16	-767	69	-753	0
6 Diamond Hd	-524	-338	6	188	1003	-302	-371	133	244	-189	-256	69	146	-131	92	49	-99	-33	7	-92	152	78	168	0
7 Kaimuki	-477	122	479	81	218	-525	-859	837	220	-177	-536	596	303	-313	145	-122	-25	-128	21	30	142	-50	18	0
8 Manoa	260	59	263	-595	199	222	261	-946	-26	-106	312	-144	-38	215	-192	87	-6	26	13	17	29	-60	150	0
9 Nuuanu	719	-150	83	80	-259	136	196	-505	-551	1	-322	282	402	-5	-140	139	-305	-27	9	22	256	-163	102	0
10 Kalihi	559	-1030	111	-431	-1281	-64	7	-47	-163	5	-118	916	770	121	281	157	-388	-32	22	29	363	102	111	0
11 Iwilei	253	-193	135	-565	-679	122	156	187	325	433	165	597	-483	346	189	139	-888	15	16	-43	314	-388	-153	0
12 Airport PH	-88	178	124	305	267	94	74	171	151	114	306	-1910	235	-407	-45	213	47	36	18	18	-16	51	64	0
13 Salt Lake	-937	151	-580	-90	41	-262	-53	245	-621	310	-3	1508	-801	983	-177	-538	365	103	43	53	303	-234	191	0
14 PC Aiea	-2179	251	-144	-729	142	-267	160	444	-213	-164	-356	-1623	574	1495	245	1328	96	281	-60	139	146	283	151	0
15 Waipahu	-697	222	110	-516	-603	154	58	143	-294	133	-260	-1032	359	-667	1092	798	1152	-206	-55	76	-98	-9	140	0
16 Mililani	226	-130	28	-553	-79	-15	-182	333	434	278	135	-15	-869	447	281	-1276	1018	-158	224	242	-868	378	121	0
17 Ewa	-172	412	-175	65	-137	251	207	228	-664	-538	-430	373	385	-1767	288	587	166	-211	146	173	256	286	271	0
18 Waianae	1052	81	-132	-334	7	-145	103	229	-29	-11	205	-336	163	450	-545	-588	-320	-144	90	145	436	-578	201	0
19 NorthShore	691	13	-21	19	170	33	66	20	118	-71	31	-80	144	16	-467	-866	166	-31	-278	-64	266	0	125	0
20 Koolauloa	-118	139	102	189	143	67	43	100	87	51	118	314	-27	-77	86	44	-412	-126	54	-1089	99	120	93	0
21 Kaneohe	1194	-437	-1002	253	-302	0	224	55	329	76	716	489	-1	-549	-479	-158	407	198	77	102	-1395	51	152	0
22 Kailua	172	-705	-377	52	129	-60	84	-290	591	-122	299	21	-642	-36	-9	417	-289	173	-135	70	435	16	206	0
23 E Honolulu	-774	-319	173	236	175	78	-516	-616	486	-382	-133	611	176	71	-216	-387	280	190	70	110	561	228	-102	0
Totals	-44	3	-3	-5	10	-3	-9	14	8	2	17	4	4	25	-3	31	44	-9	-19	0	-47	-12	-8	0

Journey-to-Work Home-Based Work All-Veh
Estimated Trips / Observed Trips

Production District	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
1 Downtown	.8	3.4	1.2	1.6	.4	.0	.7	.0	.6	1.2	3.2	2.4	.0	2.6	.0	.0	.0	.0	.0	.0	.0	.4	.0	1.0
2 Kakaako	1.3	1.1	.0	2.5	.4	.0	.0	.0	3.0	.0	.6	.5	.2	.0	.1	.0	.0	.0	.0	.0	.5	.0	.0	1.0
3 Makiki	1.2	1.0	.8	1.1	1.9	.7	.0	.5	.9	1.2	1.2	.9	.6	1.0	.6	.3	.4	.0	.0	.0	2.3	.7	.2	1.0
4 McCully	1.2	1.9	2.0	1.0	1.1	4.2	.6	.9	2.6	2.2	.6	1.3	.5	.8	.5	.0	.3	.0	.0	.0	.2	.5	.4	1.0
5 Waikiki	1.1	1.6	1.0	1.8	1.2	1.3	3.3	1.3	.5	.0	1.2	.4	.5	.4	.3	.0	.1	.0	.0	.0	.2	.0	.2	1.0
6 Diamond Hd	.9	.7	1.0	1.1	1.7	.8	.6	1.2	3.0	.5	.8	1.1	3.9	.7	.0	2.2	.4	.5	.0	.2	.0	.0	1.9	1.0
7 Kaimuki	.9	1.2	1.8	1.0	1.1	.6	.6	2.4	1.6	.6	.7	1.9	.0	.6	.0	.6	.8	.3	.0	.0	2.4	.7	1.0	1.0
8 Manoa	1.1	1.1	1.7	.7	1.3	6.8	.0	.5	.9	.6	1.9	.8	.8	.0	.3	.0	.9	.0	.0	.0	1.3	.5	.0	1.0
9 Nuuanu	1.1	.9	1.1	1.1	.8	2.2	.0	.5	.7	1.0	.9	1.2	.0	1.0	.5	8.3	.3	.6	.0	.0	2.3	.6	3.5	1.0
10 Kalihi	1.1	.4	1.2	.7	.4	.8	1.0	.9	.9	1.0	1.0	1.5	.0	1.2	.0	2.9	.3	.5	.0	.0	2.4	2.3	5.4	1.0
11 Iwilei	1.1	.8	1.3	.6	.5	.0	.0	.0	2.3	.0	1.1	1.4	.6	2.6	.0	.0	.1	.0	.0	.3	.0	.1	.4	1.0
12 Airport PH	.9	2.8	3.2	.0	.0	.0	.0	.0	4.8	3.4	1.3	.8	1.7	.7	1.0	4.2	1.3	.0	.0	.0	.9	.0	.0	1.0
13 Salt Lake	.8	1.2	.5	.9	1.1	.5	.8	2.1	.5	2.5	1.0	1.3	.8	1.4	.8	.6	3.3	.0	.0	.0	3.0	.4	.0	1.0
14 PC Aiea	.7	1.3	.8	.6	1.2	.6	1.9	3.2	.7	.8	.9	.9	1.3	1.2	1.1	1.7	1.0	7.7	.7	.0	1.3	.0	1.9	1.0
15 Waipahu	.8	1.9	1.5	.8	.8	.0	1.7	2.1	.5	2.2	.9	.8	2.0	.8	1.3	1.4	1.8	.5	.7	.0	.8	.9	.0	1.0
16 Mililani	1.1	.9	1.1	.6	.9	1.0	.6	2.9	7.8	3.8	1.1	1.0	.5	1.2	1.1	.9	1.8	.7	1.5	.0	.5	.0	1.6	1.0
17 Ewa	.9	2.4	.7	1.1	.9	32.4	.0	2.2	.4	.4	.8	1.1	2.1	.6	1.1	1.2	1.0	.9	.0	.0	1.9	.0	.0	1.0
18 Waianae	5.9	1.3	.6	.6	1.0	.5	.0	.0	.9	.9	1.4	.9	2.7	2.9	.5	.5	.8	1.0	.0	.0	.0	.3	.0	1.0
19 NorthShore	10.0	1.1	.9	1.1	2.0	1.6	.0	1.2	.0	.5	1.1	.9	10.0	1.0	.5	.7	2.0	.8	.9	.8	.0	1.0	.0	1.0
20 Koolauloa	.8	.0	.0	.0	2.1	.0	.0	.0	.0	.0	1.7	3.1	.8	.7	2.6	1.2	.3	.4	1.4	.8	1.4	.0	.0	1.0
21 Kaneohe	1.3	.7	.4	1.3	.8	1.0	.0	1.2	1.5	1.1	1.4	1.2	1.0	.7	.5	.8	.0	.0	.0	1.7	.9	1.0	2.9	1.0
22 Kailua	1.0	.6	.6	1.1	1.2	.8	1.9	.5	2.8	.8	1.2	1.0	.4	.9	1.0	.0	.5	.0	.4	2.1	1.1	1.0	1.6	1.0
23 E Honolulu	.8	.8	1.2	1.1	1.1	1.1	.6	.7	5.0	.5	.9	1.5	1.8	1.1	.6	.5	5.8	.0	.0	.0	.0	1.7	1.0	1.0
Totals	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0


Total Journey-to-Work HBW (all Veh)
Obs Avg TL = 19.384
Est Avg TL = 19.399
Percent of trips
10.0%
8.0%
6.0%
4.0%
2.0%
0.0%
2
10
18
26
34
42
50
58
66
74
82
90
98
106
114
Trip Time
Obs
Est

Estimated Trips
Journey-to-Work Home-Based Non-Work

Production District	Attraction District 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
1 Downtown	1142	187	292	200	32	36	25	33	306	90	173	53	34	15	0	2	2	0	0	0	7	4	12	2645
2 Kakaako	156	107	159	170	24	18	11	18	34	8	14	7	5	3	0	0	0	0	0	0	1	1	4	740
3 Makiki	1086	390	1877	1074	158	182	125	335	396	114	142	79	42	25	3	2	3	2	0	0	10	5	54	6104
4 McCully	522	346	1140	1796	340	281	196	358	159	58	70	46	24	12	3	1	1	1	0	1	6	5	68	5434
5 Waikiki	391	318	718	1334	652	210	130	203	100	36	49	30	17	11	2	1	2	2	0	0	5	4	39	4254
6 Diamond Hd	216	96	517	568	294	1572	425	378	108	45	48	41	22	11	1	4	0	2	2	2	5	3	147	4507
7 Kaimuki	492	158	1070	847	251	989	2085	732	238	99	108	98	51	31	7	11	5	5	2	2	17	10	266	7574
8 Manoa	209	76	530	384	79	143	102	1593	112	37	42	41	21	13	4	4	3	2	1	1	7	3	48	3455
9 Nuuanu	1580	292	842	474	77	119	86	178	1543	345	293	144	90	50	4	8	3	4	2	1	47	36	43	6261
10 Kalihi	1070	183	371	236	43	113	78	85	816	1554	789	503	295	150	14	19	5	8	0	2	93	25	42	6494
11 Iwilei	349	59	93	132	12	26	20	17	140	177	323	124	65	28	2	1	4	0	0	0	9	3	7	1591
12 Airport PH	123	29	52	47	9	23	18	28	49	76	131	1415	181	144	15	13	5	2	1	1	8	3	16	2389
13 Salt Lake	484	96	245	188	44	104	75	108	222	314	446	1952	1896	836	80	65	19	11	6	2	38	15	48	7294
14 PC Aiea	590	161	332	324	96	171	136	210	255	311	428	2421	1079	7957	856	488	155	48	26	14	90	56	113	16317
15 Waipahu	341	90	178	175	48	100	73	113	143	160	233	892	284	1989	3248	1283	466	37	21	9	53	28	63	10027
16 Mililani	359	119	247	254	91	135	107	170	173	133	182	606	214	841	876	8270	136	55	124	20	98	70	114	13394
17 Ewa	308	102	212	213	80	105	88	144	141	119	650	482	170	509	998	306	3291	62	22	19	82	56	102	8261
18 Waianae	170	65	141	142	55	78	58	97	92	49	60	150	68	93	53	69	69	2136	18	10	64	43	75	3855
19 NorthShore	130	48	110	109	39	60	47	76	65	39	47	113	48	65	31	256	24	25	954	62	46	33	54	2481
20 Koolauloa	48	19	47	42	16	24	18	30	29	19	19	43	19	21	9	18	8	10	8	1027	42	13	22	1551
21 Kaneohe	785	199	411	336	430	141	111	169	594	550	358	424	222	164	35	80	36	45	19	44	6887	998	91	13129
22 Kailua	710	171	366	290	77	117	88	137	549	170	148	188	92	77	29	64	26	33	20	14	1221	5558	150	10295
23 E Honolulu	1120	199	898	729	428	857	514	583	271	125	144	217	102	83	31	70	34	36	15	15	90	125	4817	11503
Totals	12381	3510	10848	10064	3375	5604	4616	5795	6535	4628	4897	10069	5041	13128	6301	11035	4297	2526	1241	1246	8926	7097	6395	149555

Observed Trips
Journey-to-Work Home-Based Non-Work

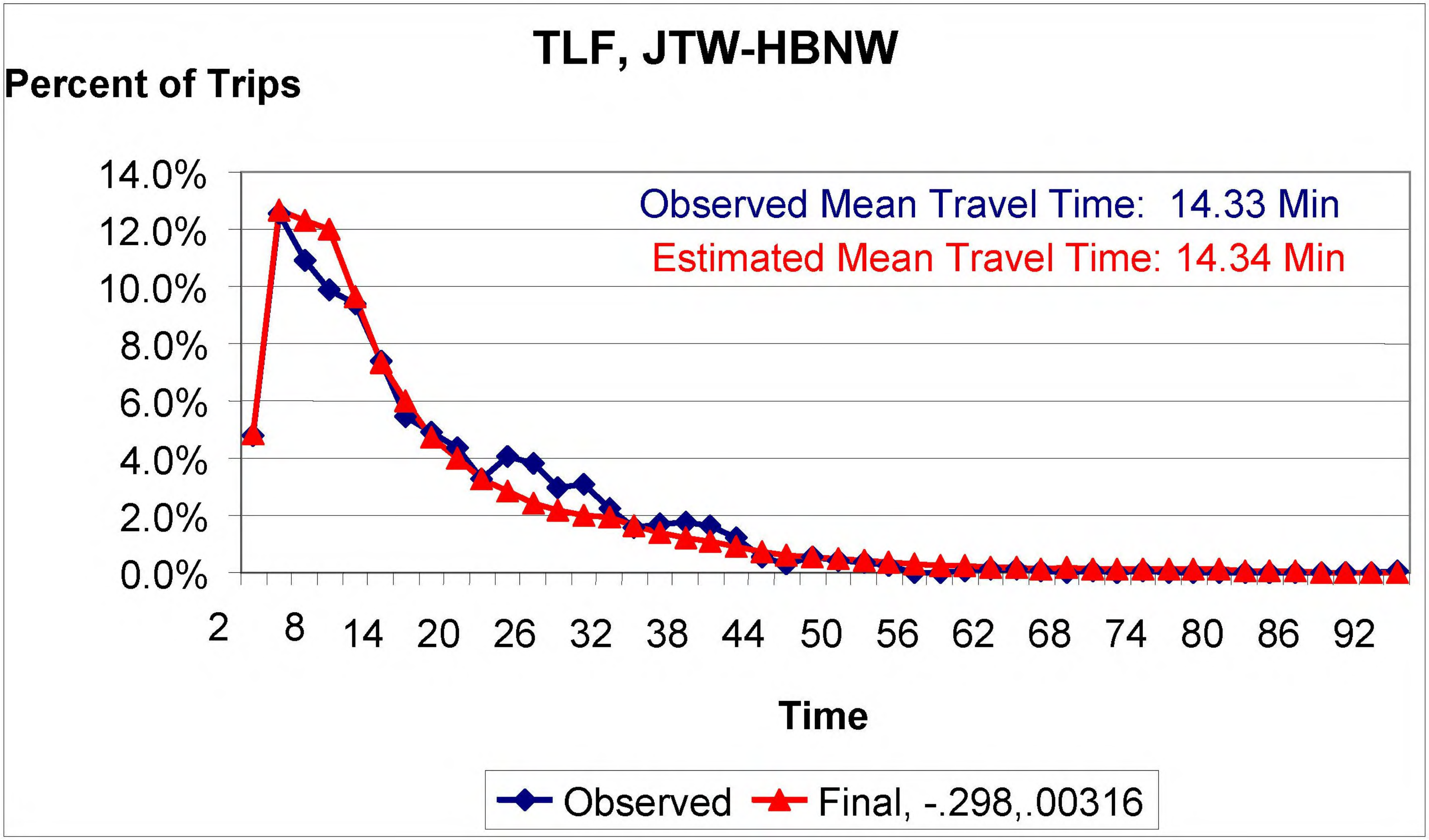
Production District	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
	Attraction District																							
1 Downtown	701	503	204	259	106	103	26	0	103	51	249	51	0	58	58	0	0	0	0	0	0	173	0	2645
2 Kakaako	40	0	0	0	0	0	0	0	306	0	253	141	0	0	0	0	0	0	0	0	0	0	0	740
3 Makiki	1344	258	1323	1323	407	103	41	403	20	134	67	186	0	0	0	0	0	0	0	0	0	276	219	6104
4 McCully	535	0	1259	1903	16	252	307	172	342	0	223	221	143	0	61	0	0	0	0	0	0	0	0	5434
5 Waikiki	217	0	316	1156	1288	384	161	0	0	0	187	103	0	0	0	0	36	0	0	0	0	0	406	4254
6 Diamond Hd	563	352	578	633	345	934	171	393	250	73	68	51	0	0	0	0	0	0	0	0	0	0	96	4507
7 Kaimuki	208	36	893	697	139	1717	2268	290	100	0	391	199	0	139	0	0	0	0	0	0	98	39	360	7574
8 Manoa	88	151	351	411	228	59	0	1843	62	0	92	78	0	0	0	44	0	0	0	0	0	0	48	3455
9 Nuuanu	1443	165	752	570	230	144	0	346	1358	316	423	143	27	147	48	19	0	0	0	0	0	54	76	6261
10 Kalihi	1150	241	528	632	0	190	99	32	737	1973	437	210	0	63	29	121	52	0	0	0	0	0	0	6494
11 Iwilei	348	0	269	61	36	36	0	85	0	0	343	169	85	0	68	0	0	0	0	0	0	91	0	1591
12 Airport PH	303	0	0	0	0	0	0	0	0	0	106	1455	210	81	111	0	0	0	37	0	0	86	0	2389
13 Salt Lake	416	116	59	103	0	123	164	395	598	232	314	1650	2403	518	49	68	0	0	0	0	0	86	0	7294
14 PC Aiea	800	339	551	414	71	95	129	306	570	597	211	2219	1062	7737	231	332	128	162	0	0	166	0	197	16317
15 Waipahu	516	177	364	318	112	0	43	29	244	193	247	842	228	2437	3371	653	145	0	108	0	0	0	0	10027
16 Mililani	328	328	475	210	98	28	87	80	0	91	348	550	280	892	748	8625	185	0	0	0	0	41	0	13394
17 Ewa	226	0	50	0	137	0	132	596	598	581	159	807	268	539	650	300	3218	0	0	0	0	0	0	8261
18 Waianae	0	48	39	0	0	0	0	0	0	54	0	177	0	0	834	0	185	2364	0	0	154	0	0	3855
19 NorthShore	53	77	138	0	0	0	0	0	0	0	0	0	0	46	0	748	247	0	1080	92	0	0	0	2481
20 Koolauloa	73	0	0	0	0	0	0	0	0	0	0	172	0	0	0	0	0	0	17	1155	134	0	0	1551
21 Kaneohe	1176	353	926	203	0	10	0	226	479	281	123	432	166	419	14	0	81	0	0	0	7124	1034	82	13129
22 Kailua	742	217	717	615	0	307	29	190	378	0	300	136	96	0	0	0	0	0	0	0	1258	5218	92	10295
23 E Honolulu	1113	158	1093	581	184	1127	960	444	396	55	366	54	63	0	0	55	0	0	0	0	0	0	4854	11503
Totals	12383	3519	10885	10089	3397	5612	4617	5830	6541	4631	4907	10046	5031	13076	6272	10965	4277	2526	1242	1247	8934	7098	6430	149555

Estimated Trips - Observed Trips
Journey-to-Work Home-Based Non-Work

Production District	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
	Attraction District																							
1 Downtown	441	-316	88	-59	-74	-67	-1	33	203	39	-76	2	34	-43	-58	2	2	0	0	0	7	-169	12	0
2 Kakaako	116	107	159	170	24	18	11	18	-272	8	-239	-134	5	3	0	0	0	0	0	0	1	1	4	0
3 Makiki	-258	132	554	-249	-249	79	84	-68	376	-20	75	-107	42	25	3	2	3	2	0	0	10	-271	-165	0
4 McCully	-13	346	-119	-107	324	29	-111	186	-183	58	-153	-175	-119	12	-58	1	1	1	0	1	6	5	68	0
5 Waikiki	174	318	402	178	-636	-174	-31	203	100	36	-138	-73	17	11	2	1	-34	2	0	0	5	4	-367	0
6 Diamond Hd	-347	-256	-61	-65	-51	638	254	-15	-142	-28	-20	-10	22	11	1	4	0	2	2	2	5	3	51	0
7 Kaimuki	284	122	177	150	112	-728	-183	442	138	99	-283	-101	51	-108	7	11	5	5	2	2	-81	-29	-94	0
8 Manoa	121	-75	179	-27	-149	84	102	-250	50	37	-50	-37	21	13	4	-40	3	2	1	1	7	3	0	0
9 Nuuanu	137	127	90	-96	-153	-25	86	-168	185	29	-130	1	63	-97	-44	-11	3	4	2	1	47	-18	-33	0
10 Kalihi	-80	-58	-157	-396	43	-77	-21	53	79	-419	352	293	295	87	-15	-102	-47	8	0	2	93	25	42	0
11 Iwilei	1	59	-176	71	-24	-10	20	-68	140	177	-20	-45	-20	28	-66	1	4	0	0	0	9	-88	7	0
12 Airport PH	-180	29	52	47	9	23	18	28	49	76	25	-40	-29	63	-96	13	5	2	-36	1	8	-83	16	0
13 Salt Lake	68	-20	186	85	44	-19	-89	-287	-376	82	132	302	-507	318	31	-3	19	11	6	2	38	-71	48	0
14 PC Aiea	-210	-178	-219	-90	25	76	7	-96	-315	-286	217	202	17	220	625	156	27	-114	26	14	-76	56	-84	0
15 Waipahu	-175	-87	-186	-143	-64	100	30	84	-101	-33	-14	50	56	-448	-123	630	321	37	-87	9	53	28	63	0
16 Mililani	31	-209	-228	44	-7	107	20	90	173	42	-166	56	-66	-51	128	-355	-49	55	124	20	98	29	114	0
17 Ewa	82	102	162	213	-57	105	-44	-452	-457	-462	491	-325	-98	-30	348	6	73	62	22	19	82	56	102	0
18 Waianae	170	17	102	142	55	78	58	97	92	-5	60	-27	68	93	-781	69	-116	-228	18	10	-90	43	75	0
19 NorthShore	77	-29	-28	109	39	60	47	76	65	39	47	113	48	19	31	-492	-223	25	-126	-30	46	33	54	0
20 Koolauloa	-25	19	47	42	16	24	18	30	29	19	19	-129	19	21	9	18	8	10	-9	-128	-92	13	22	0
21 Kaneohe	-391	-154	-515	133	430	131	111	-57	115	269	235	-8	56	-255	21	80	-45	45	19	44	-237	-36	9	0
22 Kailua	-32	-46	-351	-325	77	-190	59	-53	171	170	-152	52	-4	77	29	64	26	33	20	14	-37	340	58	0
23 E Honolulu	7	41	-195	148	244	-270	-446	139	-125	70	-222	163	39	83	31	15	34	36	15	15	90	125	-37	0
Totals	-2	-9	-37	-25	-22	-8	-1	-35	-6	-3	-10	23	10	52	29	70	20	0	-1	-1	-8	-1	-35	0

Estimated Trips / Observed Trips
Journey-to-Work Home-Based Non-Work

Production District	Attraction District 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
1 Downtown	1.6	.4	1.4	.8	.3	.3	1.0	.0	3.0	1.8	.7	1.0	.0	.3	.0	.0	.0	.0	.0	.0	.0	.0	.0	1.0
2 Kakaako	3.9	.0	.0	.0	.0	.0	.0	.0	.1	.0	.1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	1.0
3 Makiki	.8	1.5	1.4	.8	.4	1.8	3.0	.8	19.8	.9	2.1	.4	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.2	1.0
4 McCully	1.0	.0	.9	.9	21.3	1.1	.6	2.1	.5	.0	.3	.2	.2	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	1.0
5 Waikiki	1.8	.0	2.3	1.2	.5	.5	.8	.0	.0	.0	.3	.3	.0	.0	.0	.0	.1	.0	.0	.0	.0	.0	.1	1.0
6 Diamond Hd	.4	.3	.9	.9	.9	1.7	2.5	1.0	.4	.6	.7	.8	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	1.5	1.0
7 Kaimuki	2.4	4.4	1.2	1.2	1.8	.6	.9	2.5	2.4	.0	.3	.5	.0	.2	.0	.0	.0	.0	.0	.0	.2	.3	.7	1.0
8 Manoa	2.4	.5	1.5	.9	.3	2.4	.0	.9	1.8	.0	.5	.5	.0	.0	.0	.1	.0	.0	.0	.0	.0	.0	1.0	1.0
9 Nuuanu	1.1	1.8	1.1	.8	.3	.8	.0	.5	1.1	1.1	.7	1.0	3.3	.3	.1	.4	.0	.0	.0	.0	.0	.7	.6	1.0
10 Kalihi	.9	.8	.7	.4	.0	.6	.8	2.7	1.1	.8	1.8	2.4	.0	2.4	.5	.2	.1	.0	.0	.0	.0	.0	.0	1.0
11 Iwilei	1.0	.0	.3	2.2	.3	.7	.0	.2	.0	.0	.9	.7	.8	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	1.0
12 Airport PH	.4	.0	.0	.0	.0	.0	.0	.0	.0	.0	1.2	1.0	.9	1.8	.1	.0	.0	.0	.0	.0	.0	.0	.0	1.0
13 Salt Lake	1.2	.8	4.2	1.8	.0	.8	.5	.3	.4	1.4	1.4	1.2	.8	1.6	1.6	1.0	.0	.0	.0	.0	.0	.2	.0	1.0
14 PC Aiea	.7	.5	.6	.8	1.4	1.8	1.1	.7	.4	.5	2.0	1.1	1.0	1.0	3.7	1.5	1.2	.3	.0	.0	.5	.0	.6	1.0
15 Waipahu	.7	.5	.5	.6	.4	.0	1.7	3.9	.6	.8	.9	1.1	1.2	.8	1.0	2.0	3.2	.0	.2	.0	.0	.0	.0	1.0
16 Mililani	1.1	.4	.5	1.2	.9	4.8	1.2	2.1	.0	1.5	.5	1.1	.8	.9	1.2	1.0	.7	.0	.0	.0	.0	1.7	.0	1.0
17 Ewa	1.4	.0	4.2	.0	.6	.0	.7	.2	.2	.2	4.1	.6	.6	.9	1.5	1.0	1.0	.0	.0	.0	.0	.0	.0	1.0
18 Waianae	.0	1.4	3.6	.0	.0	.0	.0	.0	.0	.9	.0	.8	.0	.0	.1	.0	.4	.9	.0	.0	.4	.0	.0	1.0
19 NorthShore	2.5	.6	.8	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	1.4	.0	.3	.1	.0	.9	.7	.0	.0	.0	1.0
20 Koolauloa	.7	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.3	.0	.0	.0	.0	.0	.0	.5	.9	.3	.0	.0	1.0
21 Kaneohe	.7	.6	.4	1.7	.0	14.1	.0	.7	1.2	2.0	2.9	1.0	1.3	.4	2.5	.0	.4	.0	.0	.0	1.0	1.0	1.1	1.0
22 Kailua	1.0	.8	.5	.5	.0	.4	3.0	.7	1.5	.0	.5	1.4	1.0	.0	.0	.0	.0	.0	.0	.0	1.0	1.1	1.6	1.0
23 E Honolulu	1.0	1.3	.8	1.3	2.3	.8	.5	1.3	.7	2.3	.4	4.0	1.6	.0	.0	1.3	.0	.0	.0	.0	.0	.0	1.0	1.0
Totals	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0



TLF, JTW-HBNW
Percent of Trips
14.0%
12.0%
10.0%
8.0%
6.0%
4.0%
2.0%
0.0%
Observed Mean Travel Time: 14.33 Min
Estimated Mean Travel Time: 14.34 Min
2
8
14
20
26
32
38
44
50
56
62
68
74
80
86
92
Time
Observed
Final, -.298,.00316

Estimated Trips
Journey-to-Work Work-Based

Production District	Attraction District 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
1 Downtown	5064	1581	1051	993	647	202	163	337	517	232	1379	674	323	233	66	57	40	5	9	8	159	123	45	13908
2 Kakaako	1039	626	339	424	316	69	52	116	107	45	264	139	72	47	18	10	11	1	3	1	33	27	16	3775
3 Makiki	2833	1249	1360	1506	1043	317	250	698	360	185	803	530	269	198	55	46	41	6	5	8	124	94	67	12047
4 McCully	1173	1267	1002	3823	1376	332	266	653	244	128	573	383	191	140	44	37	31	6	6	3	93	69	63	11903
5 Waikiki	546	354	262	466	855	168	97	197	65	36	154	107	52	42	10	15	9	1	1	3	27	22	20	3509
6 Diamond Hd	748	326	390	513	643	553	324	473	133	73	297	225	108	84	26	21	22	5	3	3	56	38	87	5151
7 Kaimuki	563	220	288	362	382	296	610	365	97	51	220	168	82	56	21	19	13	4	2	2	41	29	57	3948
8 Manoa	749	329	405	521	462	210	173	1811	120	66	284	213	103	78	25	21	19	4	3	5	52	36	44	5733
9 Nuuanu	1911	551	466	421	288	113	93	190	651	188	744	427	221	161	46	36	29	7	4	4	135	109	25	6820
10 Kalihi	958	271	194	177	129	65	52	83	248	321	791	623	315	223	68	42	37	8	4	7	152	68	12	4848
11 Iwilei	1230	362	247	232	159	65	51	97	176	165	1231	668	249	177	58	44	34	4	5	5	90	40	16	5405
12 Airport PH	1182	362	249	277	200	124	96	205	174	198	1375	4020	851	922	283	188	160	20	20	9	140	60	34	11149
13 Salt Lake	571	174	129	136	103	66	52	98	90	113	642	1205	1095	466	130	92	73	10	10	6	83	33	14	5391
14 PC Aiea	881	290	199	237	175	113	85	175	135	147	952	2178	903	2642	1187	667	551	47	50	19	124	61	31	11849
15 Waipahu	309	104	69	80	65	40	28	63	46	48	307	615	190	634	1253	456	670	42	30	7	48	27	10	5141
16 Mililani	478	168	122	140	120	64	50	107	74	72	445	869	269	761	1037	4533	540	64	244	35	92	56	21	10361
17 Ewa	243	86	66	71	63	34	27	50	41	38	224	410	125	297	666	285	1777	71	29	13	49	29	10	4704
18 Waianae	77	32	27	28	28	18	9	21	14	10	56	96	34	63	79	56	176	1295	13	16	28	25	9	2210
19 NorthShore	55	21	20	16	21	6	5	16	6	9	40	68	26	50	50	335	46	13	804	56	20	13	5	1701
20 Koolauloa	23	10	7	10	10	4	3	7	8	5	20	24	12	9	10	14	8	7	45	642	41	12	3	934
21 Kaneohe	926	295	215	211	169	72	56	109	211	199	563	485	234	188	68	65	58	19	14	72	3342	994	22	8587
22 Kailua	1344	226	170	167	125	48	35	75	157	81	244	178	81	75	32	31	30	12	11	24	890	2308	39	6383
23 E Honolulu	1198	282	338	402	384	324	222	393	111	69	284	242	116	88	33	36	31	13	9	13	84	138	637	5447
Totals	24101	9186	7615	11213	7763	3303	2799	6339	3785	2479	11892	14547	5921	7634	5265	7106	4406	1664	1324	961	5903	4411	1287	150904

Observed Trips
Journey-to-Work Work-Based

Production District	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
1 Downtown	5890	2058	510	619	632	187	111	193	220	0	1604	476	512	346	0	94	223	0	0	73	0	160	0	13908
2 Kakaako	1030	709	187	279	855	0	66	63	32	38	226	0	53	0	107	84	0	0	0	0	0	46	0	3775
3 Makiki	2529	1190	1692	1309	538	192	685	1045	321	417	771	367	98	237	40	0	144	0	0	0	266	93	113	12047
4 McCully	1977	1418	773	3044	1049	169	118	884	311	430	638	335	119	101	58	211	118	0	0	0	58	92	0	11903
5 Waikiki	688	0	247	376	1177	266	0	0	202	0	150	199	0	139	0	0	0	0	0	0	65	0	0	3509
6 Diamond Hd	407	478	485	541	925	654	169	617	0	260	327	0	80	71	137	0	0	0	0	0	0	0	0	5151
7 Kaimuki	485	79	310	501	293	653	581	117	137	136	496	0	53	73	0	0	0	34	0	0	0	0	0	3948
8 Manoa	614	19	351	943	59	208	336	2125	146	0	340	108	135	60	43	161	43	0	0	0	0	42	0	5733
9 Nuuanu	1289	495	408	1088	206	68	60	250	839	269	979	305	92	62	260	0	128	0	0	0	0	0	22	6820
10 Kalihi	877	452	0	552	208	86	0	64	172	182	382	523	70	152	198	0	0	0	0	0	905	0	25	4848
11 Iwilei	922	246	26	97	295	68	87	0	337	236	1807	167	88	166	150	0	89	0	97	0	109	203	215	5405
12 Airport PH	737	308	204	74	258	96	59	148	161	68	845	5098	703	798	921	321	268	0	0	38	44	0	0	11149
13 Salt Lake	961	125	347	104	74	0	0	0	49	0	184	870	1665	282	182	271	0	0	0	0	166	0	111	5391
14 PC Aiea	604	0	570	514	170	182	92	155	192	182	1021	3005	590	2409	606	826	593	138	0	0	0	0	0	11849
15 Waipahu	537	228	87	137	0	0	0	67	41	0	185	419	332	447	1665	236	720	40	0	0	0	0	0	5141
16 Mililani	768	292	64	222	88	29	84	144	105	40	567	959	643	1215	681	4167	93	106	94	0	0	0	0	10361
17 Ewa	424	0	161	0	97	0	0	0	0	0	802	598	230	62	0	246	1896	0	188	0	0	0	0	4704
18 Waianae	0	0	218	0	0	0	0	0	0	0	115	76	0	292	152	0	0	1357	0	0	0	0	0	2210
19 NorthShore	0	108	0	0	57	0	0	0	0	50	0	37	0	57	78	491	0	0	806	17	0	0	0	1701
20 Koolauloa	85	0	0	0	0	0	0	0	0	0	0	0	0	170	0	0	0	0	0	679	0	0	0	934
21 Kaneohe	700	374	241	352	134	99	55	204	329	48	158	714	115	120	0	0	99	0	0	145	3494	1206	0	8587
22 Kailua	1091	271	263	0	66	78	29	228	163	93	46	71	211	251	0	0	0	0	144	22	793	2563	0	6383
23 E Honolulu	1482	330	434	451	585	264	245	42	25	35	266	229	129	119	0	0	0	0	0	0	0	0	811	5447
Totals	24097	9180	7578	11203	7766	3299	2777	6346	3782	2484	11909	14556	5918	7629	5278	7108	4414	1675	1329	974	5900	4405	1297	150904

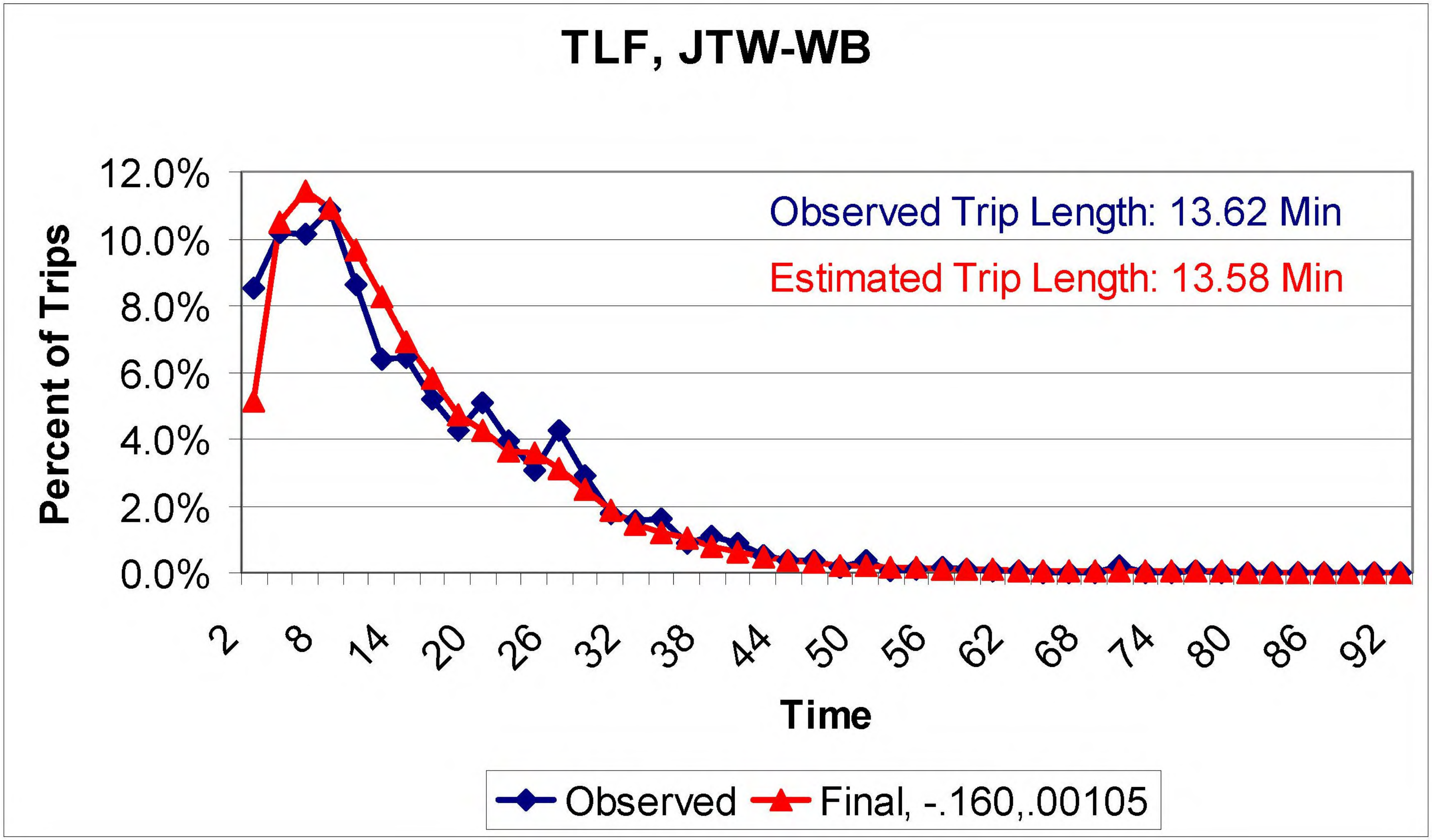
AR00076956

Estimated Trips - Observed Trips
Journey-to-Work Work-Based

Production District	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
	Attraction District																							
1 Downtown	-826	-477	541	374	15	15	52	144	297	232	-225	198	-189	-113	66	-37	-183	5	9	-65	159	-37	45	0
2 Kakaako	9	-83	152	145	-539	69	-14	53	75	7	38	139	19	47	-89	-74	11	1	3	1	33	-19	16	0
3 Makiki	304	59	-332	197	505	125	-435	-347	39	-232	32	163	171	-39	15	46	-103	6	5	8	-142	1	-46	0
4 McCully	-804	-151	229	779	327	163	148	-231	-67	-302	-65	48	72	39	-14	-174	-87	6	6	3	35	-23	63	0
5 Waikiki	-142	354	15	90	-322	-98	97	197	-137	36	4	-92	52	-97	10	15	9	1	1	3	-38	22	20	0
6 Diamond Hd	341	-152	-95	-28	-282	-101	155	-144	133	-187	-30	225	28	13	-111	21	22	5	3	3	56	38	87	0
7 Kaimuki	78	141	-22	-139	89	-357	29	248	-40	-85	-276	168	29	-17	21	19	13	-30	2	2	41	29	57	0
8 Manoa	135	310	54	-422	403	2	-163	-314	-26	66	-56	105	-32	18	-18	-140	-24	4	3	5	52	-6	44	0
9 Nuuanu	622	56	58	-667	82	45	33	-60	-188	-81	-235	122	129	99	-214	36	-99	7	4	4	135	109	3	0
10 Kalihi	81	-181	194	-375	-79	-21	52	19	76	139	409	100	245	71	-130	42	37	8	4	7	-753	68	-13	0
11 Iwilei	308	116	221	135	-136	-3	-36	97	-161	-71	-576	501	161	11	-92	44	-55	4	-92	5	-19	-163	-199	0
12 Airport PH	445	54	45	203	-58	28	37	57	13	130	530	-1078	148	124	-638	-133	-108	20	20	-29	96	60	34	0
13 Salt Lake	-390	49	-218	32	29	66	52	98	41	113	458	335	-570	184	-52	-179	73	10	10	6	-83	33	-97	0
14 PC Aiea	277	290	-371	-277	5	-69	-7	20	-57	-35	-69	-827	313	233	581	-159	-42	-91	50	19	124	61	31	0
15 Waipahu	-228	-124	-18	-57	65	40	28	-4	5	48	122	196	-142	187	-412	220	-50	2	30	7	48	27	10	0
16 Mililani	-290	-124	58	-82	32	35	-34	-37	-31	32	-122	-90	-374	-454	356	366	447	-42	150	35	92	56	21	0
17 Ewa	-181	86	-95	71	-34	34	27	50	41	38	-578	-188	-105	235	666	39	-119	71	-159	13	49	29	10	0
18 Waianae	77	32	-191	28	28	18	9	21	14	10	-59	20	34	-229	-73	56	176	-62	13	16	28	25	9	0
19 NorthShore	55	-87	20	16	-36	6	5	16	6	-41	40	31	26	-7	-28	-156	46	13	-2	39	20	13	5	0
20 Koolauloa	-62	10	7	10	10	4	3	7	8	5	20	24	12	-161	10	14	8	7	45	-37	41	12	3	0
21 Kaneohe	226	-79	-26	-141	35	-27	1	-95	-118	151	405	-229	119	68	68	65	-41	19	14	-73	-152	-212	22	0
22 Kailua	253	-45	-93	167	59	-30	6	-153	-6	-12	198	107	-130	-176	32	31	30	12	-133	2	97	-255	39	0
23 E Honolulu	-284	-48	-96	-49	-201	60	-23	351	86	34	18	13	-13	-31	33	36	31	13	9	13	84	138	-174	0
Totals	4	6	37	10	-3	4	22	-7	3	-5	-17	-9	3	5	-13	-2	-8	-11	-5	-13	3	6	-10	0

Estimated Trips / Observed Trips
Journey-to-Work Work-Based

Production District	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
	Attraction District																							
1 Downtown	.9	.8	2.1	1.6	1.0	1.1	1.5	1.7	2.3	.0	.9	1.4	.6	.7	.0	.6	.2	.0	.0	.1	.0	.8	.0	1.0
2 Kakaako	1.0	.9	1.8	1.5	.4	.0	.8	1.8	3.3	1.2	1.2	.0	1.4	.0	.2	.1	.0	.0	.0	.0	.0	.6	.0	1.0
3 Makiki	1.1	1.0	.8	1.2	1.9	1.7	.4	.7	1.1	.4	1.0	1.4	2.7	.8	1.4	.0	.3	.0	.0	.0	.5	1.0	.6	1.0
4 McCully	.6	.9	1.3	1.3	1.3	2.0	2.3	.7	.8	.3	.9	1.1	1.6	1.4	.8	.2	.3	.0	.0	.0	1.6	.8	.0	1.0
5 Waikiki	.8	.0	1.1	1.2	.7	.6	.0	.0	.3	.0	1.0	.5	.0	.3	.0	.0	.0	.0	.0	.0	.4	.0	.0	1.0
6 Diamond Hd	1.8	.7	.8	.9	.7	.8	1.9	.8	.0	.3	.9	.0	1.4	1.2	.2	.0	.0	.0	.0	.0	.0	.0	.0	1.0
7 Kaimuki	1.2	2.8	.9	.7	1.3	.5	1.0	3.1	.7	.4	.4	.0	1.5	.8	.0	.0	.0	.1	.0	.0	.0	.0	.0	1.0
8 Manoa	1.2	17.3	1.2	.6	7.8	1.0	.5	.9	.8	.0	.8	2.0	.8	1.3	.6	.1	.4	.0	.0	.0	.0	.9	.0	1.0
9 Nuuanu	1.5	1.1	1.1	.4	1.4	1.7	1.5	.8	.8	.7	.8	1.4	2.4	2.6	.2	.0	.2	.0	.0	.0	.0	.0	1.1	1.0
10 Kalihi	1.1	.6	.0	.3	.6	.8	.0	1.3	1.4	1.8	2.1	1.2	4.5	1.5	.3	.0	.0	.0	.0	.0	.2	.0	.5	1.0
11 Iwilei	1.3	1.5	9.5	2.4	.5	1.0	.6	.0	.5	.7	.7	4.0	2.8	1.1	.4	.0	.4	.0	.1	.0	.8	.2	.1	1.0
12 Airport PH	1.6	1.2	1.2	3.7	.8	1.3	1.6	1.4	1.1	2.9	1.6	.8	1.2	1.2	.3	.6	.6	.0	.0	.2	3.2	.0	.0	1.0
13 Salt Lake	.6	1.4	.4	1.3	1.4	.0	.0	.0	1.8	.0	3.5	1.4	.7	1.7	.7	.3	.0	.0	.0	.0	.5	.0	.1	1.0
14 PC Aiea	1.5	.0	.3	.5	1.0	.6	.9	1.1	.7	.8	.9	.7	1.5	1.1	2.0	.8	.9	.3	.0	.0	.0	.0	.0	1.0
15 Waipahu	.6	.5	.8	.6	.0	.0	.0	.9	1.1	.0	1.7	1.5	.6	1.4	.8	1.9	.9	1.0	.0	.0	.0	.0	.0	1.0
16 Mililani	.6	.6	1.9	.6	1.4	2.2	.6	.7	.7	1.8	.8	.9	.4	.6	1.5	1.1	5.8	.6	2.6	.0	.0	.0	.0	1.0
17 Ewa	.6	.0	.4	.0	.6	.0	.0	.0	.0	.0	.3	.7	.5	4.8	.0	1.2	.9	.0	.2	.0	.0	.0	.0	1.0
18 Waianae	.0	.0	.1	.0	.0	.0	.0	.0	.0	.0	.5	1.3	.0	.2	.5	.0	.0	1.0	.0	.0	.0	.0	.0	1.0
19 NorthShore	.0	.2	.0	.0	.4	.0	.0	.0	.0	.2	.0	1.8	.0	.9	.6	.7	.0	.0	1.0	3.3	.0	.0	.0	1.0
20 Koolauloa	.3	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.1	.0	.0	.0	.0	.0	.9	.0	.0	.0	1.0
21 Kaneohe	1.3	.8	.9	.6	1.3	.7	1.0	.5	.6	4.1	3.6	.7	2.0	1.6	.0	.0	.6	.0	.0	.5	1.0	.8	.0	1.0
22 Kailua	1.2	.8	.6	.0	1.9	.6	1.2	.3	1.0	.9	5.3	2.5	.4	.3	.0	.0	.0	.0	.1	1.1	1.1	.9	.0	1.0
23 E Honolulu	.8	.9	.8	.9	.7	1.2	.9	9.4	4.4	2.0	1.1	1.1	.9	.7	.0	.0	.0	.0	.0	.0	.0	.0	.8	1.0
Totals	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0


TLF, JTW-WB
Observed Trip Length: 13.62 Min
Estimated Trip Length: 13.58 Min
Percent of Trips
12.0%
10.0%
8.0%
6.0%
4.0%
2.0%
0.0%
2
8
14
20
26
32
38
44
50
56
62
68
74
80
86
92
Time
Observed
Final, -.160,.00105

AR00076959

Estimated Trips
Journey-to-Work Non-Based

Production District	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
1 Downtown	1404	397	474	515	192	170	128	192	683	153	335	199	121	128	33	39	22	9	11	5	83	67	72	5432
2 Kakaako	314	249	198	397	173	74	49	87	141	32	65	47	29	34	6	12	8	5	3	4	20	17	34	1998
3 Makiki	470	215	703	687	250	225	159	412	376	82	112	105	69	84	17	31	14	10	4	9	48	41	83	4206
4 McCully	487	439	762	1823	699	504	364	678	370	90	123	121	79	100	21	39	23	14	10	9	64	45	155	7019
5 Waikiki	111	112	170	432	631	184	122	172	80	20	32	32	23	29	7	15	14	6	7	4	19	18	49	2289
6 Diamond Hd	90	52	182	284	224	603	349	315	97	29	37	46	29	38	6	19	12	7	5	5	25	20	133	2607
7 Kaimuki	88	41	169	225	121	420	444	292	96	26	34	45	29	34	9	19	8	7	6	6	21	22	124	2286
8 Manoa	138	67	288	391	166	274	228	1108	164	43	53	65	41	54	12	29	11	12	9	8	35	27	95	3318
9 Nuuanu	540	124	208	198	80	114	87	133	975	158	193	156	106	127	26	41	23	18	7	7	136	120	54	3631
10 Kalihi	92	21	31	34	13	30	21	24	104	154	119	100	71	79	13	21	8	4	5	5	80	23	14	1066
11 Iwilei	231	56	72	78	34	40	29	44	174	130	388	227	105	103	23	27	13	6	4	4	53	19	23	1883
12 Airport PH	113	31	41	64	30	58	43	64	92	104	246	1862	502	660	103	122	50	21	17	12	70	36	38	4379
13 Salt Lake	72	21	34	47	23	41	30	43	73	73	130	674	685	389	66	86	35	16	14	8	60	27	28	2675
14 PC Aiea	37	12	17	30	15	26	20	32	36	31	61	373	219	2026	327	265	95	20	17	10	43	27	22	3761
15 Waipahu	8	6	3	10	7	7	5	10	12	7	16	64	29	327	565	306	114	6	12	2	14	11	10	1551
16 Mililani	22	7	13	27	18	17	16	25	25	13	20	73	35	212	311	3228	88	33	100	13	52	44	32	4424
17 Ewa	13	5	12	13	10	11	9	17	16	8	15	52	25	123	185	138	1048	24	15	11	27	24	17	1818
18 Waianae	9	5	7	10	8	10	8	12	11	3	5	19	9	23	12	33	22	684	12	10	22	23	15	972
19 NorthShore	1	0	0	2	0	1	0	2	1	1	1	3	0	1	3	15	2	1	186	1	3	2	2	228
20 Koolauloa	1	2	3	4	2	2	3	2	2	2	1	4	3	7	3	9	5	4	5	159	7	6	4	240
21 Kaneohe	51	18	25	33	15	23	14	29	89	52	44	69	39	57	15	47	26	16	19	12	2935	489	29	4146
22 Kailua	32	10	17	17	17	13	13	17	64	12	15	17	13	23	11	27	15	11	11	6	367	1340	26	2094
23 E Honolulu	48	22	87	111	59	220	122	145	60	17	25	38	19	31	10	35	15	17	10	9	32	35	817	1984
Totals	4372	1912	3516	5432	2787	3067	2263	3855	3741	1240	2070	4391	2280	4689	1784	4603	1671	951	489	319	4216	2483	1876	64007

Attraction District: columns 1–23

Observed Trips
Journey-to-Work Non-Based

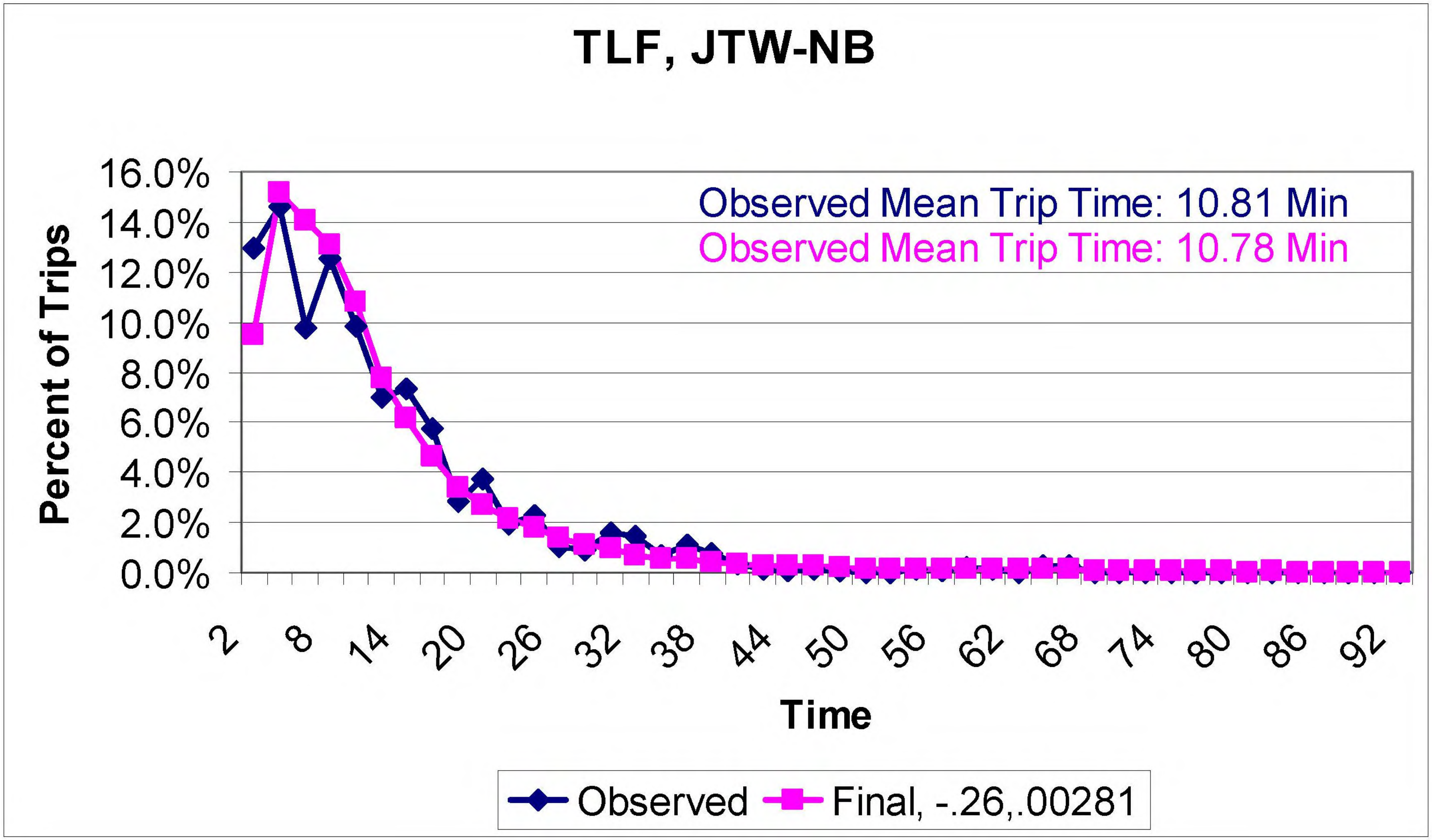
Production District	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
	Attraction District																							
1 Downtown	1540	145	416	936	336	85	176	0	467	177	385	412	0	256	0	0	63	0	0	38	0	0	0	5432
2 Kakaako	65	463	242	431	169	32	145	91	0	0	29	122	77	0	49	0	0	0	0	0	0	29	54	1998
3 Makiki	617	142	855	403	65	365	41	438	128	104	0	294	0	240	162	218	0	0	0	0	0	93	41	4206
4 McCully	433	189	247	1604	509	773	886	696	483	54	298	0	0	175	0	340	0	121	0	0	0	37	174	7019
5 Waikiki	0	349	143	488	724	79	41	99	162	60	0	95	0	49	0	0	0	0	0	0	0	0	0	2289
6 Diamond Hd	144	0	95	326	335	957	125	269	68	0	0	0	0	138	0	0	0	0	0	0	0	86	64	2607
7 Kaimuki	70	162	46	193	198	291	684	189	21	0	0	0	0	0	50	0	0	50	0	0	0	40	292	2286
8 Manoa	0	22	458	404	140	54	90	1297	254	0	0	0	0	323	76	28	0	0	0	0	115	0	57	3318
9 Nuuanu	154	101	442	297	110	0	35	164	1372	68	186	64	0	6	0	64	0	0	84	0	241	192	51	3631
10 Kalihi	89	0	0	0	60	0	0	0	128	249	0	401	0	0	0	0	139	0	0	0	0	0	0	1066
11 Iwilei	324	48	0	34	0	0	0	150	156	220	619	47	26	208	0	0	0	0	0	0	0	0	51	1883
12 Airport PH	109	73	0	124	0	71	0	0	133	0	45	1931	515	437	436	161	73	0	0	0	142	129	0	4379
13 Salt Lake	49	0	206	0	114	0	0	156	0	0	0	490	1488	52	0	0	0	0	0	0	120	0	0	2675
14 PC Aiea	114	157	0	0	0	0	0	0	0	158	63	316	77	2245	400	179	0	0	0	0	0	52	0	3761
15 Waipahu	50	0	0	49	0	0	0	0	0	64	254	0	0	462	166	292	162	0	0	52	0	0	0	1551
16 Mililani	57	0	179	0	0	0	0	0	0	0	186	110	108	70	313	3046	0	0	326	0	0	29	0	4424
17 Ewa	80	0	0	0	0	0	0	0	0	0	0	0	0	52	144	313	1229	0	0	0	0	0	0	1818
18 Waianae	0	0	0	0	0	0	50	104	0	0	0	0	0	0	0	28	0	790	0	0	0	0	0	972
19 NorthShore	0	0	0	0	0	0	0	0	84	0	0	0	0	0	0	0	0	0	90	0	0	0	54	228
20 Koolauloa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	177	63	0	0	240
21 Kaneohe	0	0	0	0	0	0	0	125	70	0	0	104	0	0	0	0	0	0	0	52	3474	321	0	4146
22 Kailua	52	63	0	0	0	116	0	48	203	79	0	0	0	0	0	0	0	0	0	0	81	1452	0	2094
23 E Honolulu	413	0	165	108	0	242	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	41	1015	1984
Totals	4360	1914	3494	5397	2760	3065	2273	3826	3729	1233	2065	4386	2291	4713	1796	4669	1666	961	500	319	4236	2501	1853	64007

Estimated Trips - Observed Trips
Journey-to-Work Non-Based

Production District	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
1 Downtown	-136	252	58	-421	-144	85	-48	192	216	-24	-50	-213	121	-128	33	39	-41	9	11	-33	83	67	72	0
2 Kakaako	249	-214	-44	-34	4	42	-96	-4	141	32	36	-75	-48	34	-43	12	8	5	3	4	20	-12	-20	0
3 Makiki	-147	73	-152	284	185	-140	118	-26	248	-22	112	-189	69	-156	-145	-187	14	10	4	9	48	-52	42	0
4 McCully	54	250	515	219	190	-269	-522	-18	-113	36	-175	121	79	-75	21	-301	23	-107	10	9	64	8	-19	0
5 Waikiki	111	-237	27	-56	-93	105	81	73	-82	-40	32	-63	23	-20	7	15	14	6	7	4	19	18	49	0
6 Diamond Hd	-54	52	87	-42	-111	-354	224	46	29	29	37	46	29	-100	6	19	12	7	5	5	25	-66	69	0
7 Kaimuki	18	-121	123	32	-77	129	-240	103	75	26	34	45	29	34	-41	19	8	-43	6	6	21	-18	-168	0
8 Manoa	138	45	-170	-13	26	220	138	-189	-90	43	53	65	41	-269	-64	1	11	12	9	8	-80	27	38	0
9 Nuuanu	386	23	-234	-99	-30	114	52	-31	-397	90	7	92	106	121	26	-23	23	18	-77	7	-105	-72	3	0
10 Kalihi	3	21	31	34	-47	30	21	24	-24	-95	119	-301	71	79	13	21	-131	4	5	5	80	23	14	0
11 Iwilei	-93	8	72	44	34	40	29	-106	18	-90	-231	180	79	-105	23	27	13	6	4	4	53	19	-28	0
12 Airport PH	4	-42	41	-60	30	-13	43	64	-41	104	201	-69	-13	223	-333	-39	-23	21	17	12	-72	-93	38	0
13 Salt Lake	23	21	-172	47	-91	41	30	-113	73	73	130	184	-803	337	66	86	35	16	14	8	-60	27	28	0
14 PC Aiea	-77	-145	17	30	15	26	20	32	36	-127	-2	57	142	-219	-73	86	95	20	17	10	43	-25	22	0
15 Waipahu	-42	6	3	-39	7	7	5	10	12	-57	-238	64	29	-135	399	14	-48	6	12	-50	14	11	10	0
16 Mililani	-35	7	-166	27	18	17	16	25	25	13	-166	-37	-73	142	-2	182	88	33	-226	13	52	15	32	0
17 Ewa	-67	5	12	13	10	11	9	17	16	8	15	52	25	71	41	-175	-181	24	15	11	27	24	17	0
18 Waianae	9	5	7	10	8	10	-42	-92	11	3	5	19	9	23	12	5	22	-106	12	10	22	23	15	0
19 NorthShore	1	0	0	2	0	1	0	2	-83	1	1	3	0	1	3	15	2	1	96	1	3	2	-52	0
20 Koolauloa	1	2	3	4	2	2	3	2	2	2	1	4	3	7	3	9	5	4	5	-18	-56	6	4	0
21 Kaneohe	51	18	25	33	15	23	14	-96	19	52	44	-35	39	57	15	47	26	16	19	-40	-539	168	29	0
22 Kailua	-20	-53	17	17	17	-103	13	-31	-139	-67	15	17	13	23	11	27	15	11	11	6	286	-112	26	0
23 E Honolulu	-365	22	-78	3	59	-22	122	145	60	17	25	38	19	31	10	35	15	17	10	9	32	-6	-198	0
Totals	12	-2	22	35	27	2	-10	29	12	7	5	5	-11	-24	-12	-66	5	-10	-11	0	-20	-18	23	0

Estimated Trips / Observed Trips
Journey-to-Work Non-Based

Production District	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
	Attraction District																							
1 Downtown	.9	2.7	1.1	.6	.6	2.0	.7	.0	1.5	.9	.9	.5	.0	.5	.0	.0	.3	.0	.0	.1	.0	.0	.0	1.0
2 Kakaako	4.8	.5	.8	.9	1.0	2.3	.3	1.0	.0	.0	2.2	.4	.4	.0	.1	.0	.0	.0	.0	.0	.0	.6	.6	1.0
3 Makiki	.8	1.5	.8	1.7	3.8	.6	3.9	.9	2.9	.8	.0	.4	.0	.3	.1	.1	.0	.0	.0	.0	.0	.4	2.0	1.0
4 McCully	1.1	2.3	3.1	1.1	1.4	.7	.4	1.0	.8	1.7	.4	.0	.0	.6	.0	.1	.0	.1	.0	.0	.0	1.2	.9	1.0
5 Waikiki	.0	.3	1.2	.9	.9	2.3	3.0	1.7	.5	.3	.0	.3	.0	.6	.0	.0	.0	.0	.0	.0	.0	.0	.0	1.0
6 Diamond Hd	.6	.0	1.9	.9	.7	.6	2.8	1.2	1.4	.0	.0	.0	.0	.3	.0	.0	.0	.0	.0	.0	.0	.2	2.1	1.0
7 Kaimuki	1.3	.3	3.7	1.2	.6	1.4	.6	1.5	4.6	.0	.0	.0	.0	.0	.2	.0	.0	.1	.0	.0	.0	.6	.4	1.0
8 Manoa	.0	3.0	.6	1.0	1.2	5.1	2.5	.9	.6	.0	.0	.0	.0	.2	.2	1.0	.0	.0	.0	.0	.3	.0	1.7	1.0
9 Nuuanu	3.5	1.2	.5	.7	.7	.0	2.5	.8	.7	2.3	1.0	2.4	.0	21.2	.0	.6	.0	.0	.1	.0	.6	.6	1.1	1.0
10 Kalihi	1.0	.0	.0	.0	.2	.0	.0	.0	.8	.6	.0	.2	.0	.0	.0	.0	.1	.0	.0	.0	.0	.0	.0	1.0
11 Iwilei	.7	1.2	.0	2.3	.0	.0	.0	.3	1.1	.6	.6	4.8	4.0	.5	.0	.0	.0	.0	.0	.0	.0	.0	.5	1.0
12 Airport PH	1.0	.4	.0	.5	.0	.8	.0	.0	.7	.0	5.5	1.0	1.0	1.5	.2	.8	.7	.0	.0	.0	.5	.3	.0	1.0
13 Salt Lake	1.5	.0	.2	.0	.2	.0	.0	.3	.0	.0	.0	1.4	.5	7.5	.0	.0	.0	.0	.0	.0	.5	.0	.0	1.0
14 PC Aiea	.3	.1	.0	.0	.0	.0	.0	.0	.0	.2	1.0	1.2	2.8	.9	.8	1.5	.0	.0	.0	.0	.0	.5	.0	1.0
15 Waipahu	.2	.0	.0	.2	.0	.0	.0	.0	.0	.1	.1	.0	.0	.7	3.4	1.0	.7	.0	.0	.0	.0	.0	.0	1.0
16 Mililani	.4	.0	.1	.0	.0	.0	.0	.0	.0	.0	.1	.7	.3	3.0	1.0	1.1	.0	.0	.3	.0	.0	1.5	.0	1.0
17 Ewa	.2	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	2.4	1.3	.4	.9	.0	.0	.0	.0	.0	.0	1.0
18 Waianae	.0	.0	.0	.0	.0	.0	.2	.1	.0	.0	.0	.0	.0	.0	.0	1.2	.0	.9	.0	.0	.0	.0	.0	1.0
19 NorthShore	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	2.1	.0	.0	.0	.0	1.0
20 Koolauloa	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.9	.1	.0	.0	1.0
21 Kaneohe	.0	.0	.0	.0	.0	.0	.0	.2	1.3	.0	.0	.7	.0	.0	.0	.0	.0	.0	.0	.2	.8	1.5	.0	1.0
22 Kailua	.6	.2	.0	.0	.0	.1	.0	.4	.3	.2	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	4.5	.9	.0	1.0
23 E Honolulu	.1	.0	.5	1.0	.0	.9	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.9	.8	1.0
Totals	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0



TLF, JTW-NB
Observed Mean Trip Time: 10.81 Min
Observed Mean Trip Time: 10.78 Min
Percent of Trips
16.0%
14.0%
12.0%
10.0%
8.0%
6.0%
4.0%
2.0%
0.0%
2
8
14
20
26
32
38
44
50
56
62
68
74
80
86
92
Time
Observed
Final, -.26,.00281

Estimated Trips
Journey-at-Work Work Based

Production District	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
	Attraction District																							
1 Downtown	16049	1405	1526	1840	554	350	435	344	1135	249	1868	1124	243	397	94	104	47	12	10	6	260	211	338	28601
2 Kakaako	1516	2679	1150	1061	347	138	171	133	258	98	444	278	58	101	26	34	15	7	2	2	70	55	139	8782
3 Makiki	1312	602	647	776	255	140	168	167	189	89	268	230	53	79	19	25	10	4	3	0	55	39	121	5251
4 McCully	1332	931	788	4051	631	289	312	279	209	107	285	289	66	105	26	39	17	5	5	0	69	48	221	10104
5 Waikiki	676	535	407	950	1240	296	232	170	110	58	159	167	39	64	18	30	14	5	4	1	49	31	155	5410
6 Diamond Hd	254	105	127	217	205	445	286	112	55	28	74	79	15	34	8	17	5	3	3	1	24	15	206	2318
7 Kaimuki	289	110	148	223	135	177	972	125	55	29	81	86	17	31	10	13	5	5	0	0	26	17	195	2749
8 Manoa	618	239	336	482	229	208	266	2002	125	62	172	178	37	62	19	25	12	4	3	2	49	32	179	5341
9 Nuuanu	1006	256	195	222	83	64	78	66	553	111	308	245	57	84	21	21	9	3	2	1	78	68	63	3594
10 Kalihi	186	94	68	84	37	31	35	30	98	303	261	258	56	80	20	22	11	2	2	1	69	25	30	1803
11 Iwilei	2311	627	363	462	153	121	153	129	371	387	5234	1388	239	336	78	80	35	11	2	3	198	80	132	12893
12 Airport PH	993	314	277	324	133	99	128	111	204	284	1115	7239	577	1318	261	242	109	24	13	7	202	78	132	14184
13 Salt Lake	445	151	129	157	63	44	58	53	91	133	389	1405	943	502	97	96	43	14	6	2	91	41	61	5014
14 PC Aiea	281	93	80	97	39	30	39	32	58	73	196	2260	171	2374	629	394	163	18	10	6	65	31	45	7184
15 Waipahu	88	34	30	31	17	12	13	13	18	21	64	354	43	674	1452	593	315	15	12	2	30	20	18	3869
16 Mililani	78	35	21	40	15	16	16	17	17	22	55	260	38	376	594	6770	146	24	131	4	51	25	41	8792
17 Ewa	54	22	19	25	10	5	11	17	10	14	35	164	25	225	470	208	2469	31	13	3	31	24	31	3916
18 Waianae	11	5	4	7	3	3	4	5	6	3	5	21	5	12	10	28	28	1272	4	3	13	11	13	1476
19 NorthShore	5	2	2	2	1	3	2	1	0	1	5	11	1	5	7	79	6	4	204	2	5	5	4	357
20 Koolauloa	14	5	6	8	5	3	6	3	3	3	8	23	5	14	8	32	15	11	6	279	19	13	16	505
21 Kaneohe	151	55	37	54	21	17	22	19	48	51	91	132	28	61	18	41	19	12	5	2	3266	478	33	4661
22 Kailua	233	70	48	62	28	23	26	24	72	31	69	100	22	38	19	43	22	11	7	4	656	2747	73	4428
23 E Honolulu	188	74	88	137	74	99	190	72	35	21	57	75	17	32	12	25	13	9	4	0	30	39	1731	3022
Totals	28090	8443	6496	11312	4278	2613	3623	3924	3720	2178	11243	16366	2755	7004	3916	8961	3528	1506	451	331	5406	4133	3977	144254

Observed Trips
Journey-at-Work Work Based

Production District	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
	Attraction District																							
1 Downtown	20346	1051	870	831	630	465	118	204	525	113	1237	547	171	224	151	224	0	461	0	0	0	261	172	28601
2 Kakaako	1822	3116	96	1325	280	94	0	276	104	147	822	255	0	29	82	128	110	0	0	0	65	31	0	8782
3 Makiki	303	693	2050	962	448	0	41	25	79	0	49	128	123	60	0	0	75	0	0	0	0	215	0	5251
4 McCully	1121	1003	791	4547	442	550	226	168	0	47	337	342	0	98	62	113	0	0	0	0	0	63	194	10104
5 Waikiki	364	527	177	923	1983	124	0	0	0	0	117	150	0	128	0	0	0	61	0	0	0	41	815	5410
6 Diamond Hd	91	220	154	256	79	594	210	89	78	0	137	92	0	0	81	0	79	0	0	38	53	29	38	2318
7 Kaimuki	206	0	146	41	0	92	1355	68	199	0	246	24	107	0	0	0	0	0	0	0	51	0	214	2749
8 Manoa	317	59	834	986	0	39	0	2696	31	0	212	59	0	0	0	0	0	0	0	0	54	0	54	5341
9 Nuuanu	289	74	99	405	0	33	92	101	1735	81	176	0	0	136	58	42	55	0	0	0	0	130	88	3594
10 Kalihi	144	33	36	122	0	101	0	0	358	405	249	0	0	41	0	41	0	0	0	0	163	0	110	1803
11 Iwilei	1747	963	534	295	76	50	185	0	235	469	5458	1273	232	572	53	160	145	0	0	58	162	162	64	12893
12 Airport PH	349	326	140	289	298	59	283	59	56	505	1237	7803	391	958	751	204	186	0	0	0	196	94	0	14184
13 Salt Lake	369	70	77	0	0	0	107	0	70	96	232	2291	910	711	0	0	0	0	0	0	81	0	0	5014
14 PC Aiea	138	64	49	44	0	0	0	0	80	154	353	1898	341	2448	683	449	88	37	0	0	130	0	228	7184
15 Waipahu	92	0	353	0	0	74	55	0	0	0	115	937	0	402	1311	424	106	0	0	0	0	0	0	3869
16 Mililani	0	0	0	23	0	0	0	57	0	0	52	247	176	498	310	6906	109	183	231	0	0	0	0	8792
17 Ewa	0	55	26	0	0	29	79	0	0	44	159	0	55	316	378	123	2558	30	0	0	14	0	50	3916
18 Waianae	37	0	0	0	0	0	0	0	0	0	0	259	0	140	0	0	30	737	0	0	14	0	259	1476
19 NorthShore	0	83	0	0	0	0	0	0	0	0	0	0	26	0	0	165	0	0	83	0	0	0	0	357
20 Koolauloa	32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	141	234	76	22	0	505
21 Kaneohe	0	0	0	0	0	39	343	120	0	0	0	0	152	0	0	0	0	0	0	0	3677	330	0	4661
22 Kailua	108	31	67	126	41	0	0	0	127	0	65	70	0	0	0	0	0	0	0	0	668	2698	427	4428
23 E Honolulu	208	64	0	116	0	274	539	54	22	118	0	0	72	232	0	0	0	0	0	0	0	59	1264	3022
Totals	28083	8432	6499	11291	4277	2617	3633	3917	3699	2179	11253	16375	2756	6993	3920	8979	3541	1509	455	330	5404	4135	3977	144254

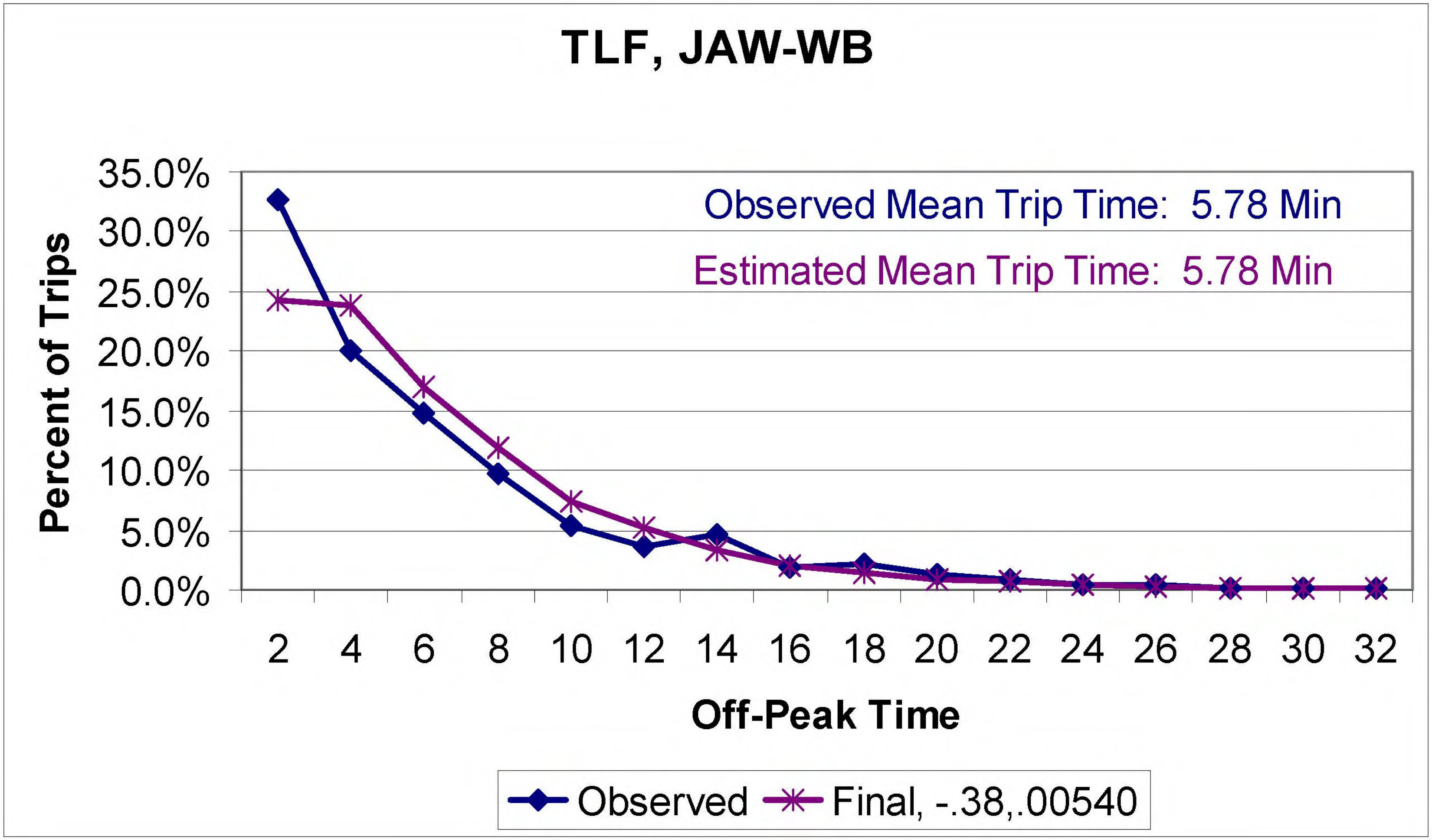
AR00076966

Estimated Trips - Observed Trips
Journey-at-Work Work Based

Production District	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
1 Downtown	-4297	354	656	1009	-76	-115	317	140	610	136	631	577	72	173	-57	-120	47	-449	10	6	260	-50	166	0
2 Kakaako	-306	-437	1054	-264	67	44	171	-143	154	-49	-378	23	58	72	-56	-94	-95	7	2	2	5	24	139	0
3 Makiki	1009	-91	-1403	-186	-193	140	127	142	110	89	219	102	-70	19	19	25	-65	4	3	0	55	-176	121	0
4 McCully	211	-72	-3	-496	189	-261	86	111	209	60	-52	-53	66	7	-36	-74	17	5	5	0	69	-15	27	0
5 Waikiki	312	8	230	27	-743	172	232	170	110	58	42	17	39	-64	18	30	14	-56	4	1	49	-10	-660	0
6 Diamond Hd	163	-115	-27	-39	126	-149	76	23	-23	28	-63	-13	15	34	-73	17	-74	3	3	-37	-29	-14	168	0
7 Kaimuki	83	110	2	182	135	85	-383	57	-144	29	-165	62	-90	31	10	13	5	5	0	0	-25	17	-19	0
8 Manoa	301	180	-498	-504	229	169	266	-694	94	62	-40	119	37	62	19	25	12	4	3	2	-5	32	125	0
9 Nuuanu	717	182	96	-183	83	31	-14	-35	-1182	30	132	245	57	-52	-37	-21	-46	3	2	1	78	-62	-25	0
10 Kalihi	42	61	32	-38	37	-70	35	30	-260	-102	12	258	56	39	20	-19	11	2	2	1	-94	25	-80	0
11 Iwilei	564	-336	-171	167	77	71	-32	129	136	-82	-224	115	7	-236	25	-80	-110	11	2	-55	36	-82	68	0
12 Airport PH	644	-12	137	35	-165	40	-155	52	148	-221	-122	-564	186	360	-490	38	-77	24	13	7	6	-16	132	0
13 Salt Lake	76	81	52	157	63	44	-49	53	21	37	157	-886	33	-209	97	96	43	14	6	2	10	41	61	0
14 PC Aiea	143	29	31	53	39	30	39	32	-22	-81	-157	362	-170	-74	-54	-55	75	-19	10	6	-65	31	-183	0
15 Waipahu	-4	34	-323	31	17	-62	-42	13	18	21	-51	-583	43	272	141	169	209	15	12	2	30	20	18	0
16 Mililani	78	35	21	17	15	16	16	-40	17	22	3	13	-138	-122	284	-136	37	-159	-100	4	51	25	41	0
17 Ewa	54	-33	-7	25	10	-24	-68	17	10	-30	-124	164	-30	-91	92	85	-89	1	13	3	17	24	-19	0
18 Waianae	-26	5	4	7	3	3	4	5	6	3	5	-238	5	-128	10	28	-2	535	4	3	-1	11	-246	0
19 NorthShore	5	-81	2	2	1	3	2	1	0	1	5	11	-25	5	7	-86	6	4	121	2	5	5	4	0
20 Koolauloa	-18	5	6	8	5	3	6	3	3	3	8	23	5	14	8	32	15	11	-135	45	-57	-9	16	0
21 Kaneohe	151	55	37	54	21	-22	-321	-101	48	51	91	132	-124	61	18	41	19	12	5	2	-411	148	33	0
22 Kailua	125	39	-19	-64	-13	23	26	24	-55	31	4	30	22	38	19	43	22	11	7	4	-12	49	-354	0
23 E Honolulu	-20	10	88	21	74	-175	-349	18	13	-97	57	75	-55	-200	12	25	13	9	4	0	30	-20	467	0
Totals	7	11	-3	21	1	-4	-10	7	21	-1	-10	-9	-1	11	-4	-18	-13	-3	-4	1	2	-2	0	0

Estimated Trips / Observed Trips
Journey-at-Work Work Based

Production District	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
	Attraction District																							
1 Downtown	.8	1.3	1.8	2.2	.9	.8	3.7	1.7	2.2	2.2	1.5	2.1	1.4	1.8	.6	.5	.0	.0	.0	.0	.0	.8	2.0	1.0
2 Kakaako	.8	.9	12.0	.8	1.2	1.5	.0	.5	2.5	.7	.5	1.1	.0	3.5	.3	.3	.1	.0	.0	.0	1.1	1.8	.0	1.0
3 Makiki	4.3	.9	.3	.8	.6	.0	4.1	6.7	2.4	.0	5.5	1.8	.4	1.3	.0	.0	.1	.0	.0	.0	.0	.2	.0	1.0
4 McCully	1.2	.9	1.0	.9	1.4	.5	1.4	1.7	.0	2.3	.8	.8	.0	1.1	.4	.3	.0	.0	.0	.0	.0	.8	1.1	1.0
5 Waikiki	1.9	1.0	2.3	1.0	.6	2.4	.0	.0	.0	.0	1.4	1.1	.0	.5	.0	.0	.0	.1	.0	.0	.0	.8	.2	1.0
6 Diamond Hd	2.8	.5	.8	.8	2.6	.7	1.4	1.3	.7	.0	.5	.9	.0	.0	.1	.0	.1	.0	.0	.0	.5	.5	5.4	1.0
7 Kaimuki	1.4	.0	1.0	5.4	.0	1.9	.7	1.8	.3	.0	.3	3.6	.2	.0	.0	.0	.0	.0	.0	.0	.5	.0	.9	1.0
8 Manoa	1.9	4.1	.4	.5	.0	5.3	.0	.7	4.0	.0	.8	3.0	.0	.0	.0	.0	.0	.0	.0	.0	.9	.0	3.3	1.0
9 Nuuanu	3.5	3.5	2.0	.5	.0	1.9	.8	.7	.3	1.4	1.8	.0	.0	.6	.4	.5	.2	.0	.0	.0	.0	.5	.7	1.0
10 Kalihi	1.3	2.8	1.9	.7	.0	.3	.0	.0	.3	.7	1.0	.0	.0	2.0	.0	.5	.0	.0	.0	.0	.4	.0	.3	1.0
11 Iwilei	1.3	.7	.7	1.6	2.0	2.4	.8	.0	1.6	.8	1.0	1.1	1.0	.6	1.5	.5	.2	.0	.0	.1	1.2	.5	2.1	1.0
12 Airport PH	2.8	1.0	2.0	1.1	.4	1.7	.5	1.9	3.6	.6	.9	.9	1.5	1.4	.3	1.2	.6	.0	.0	.0	1.0	.8	.0	1.0
13 Salt Lake	1.2	2.2	1.7	.0	.0	.0	.5	.0	1.3	1.4	1.7	.6	1.0	.7	.0	.0	.0	.0	.0	.0	1.1	.0	.0	1.0
14 PC Aiea	2.0	1.5	1.6	2.2	.0	.0	.0	.0	.7	.5	.6	1.2	.5	1.0	.9	.9	1.9	.5	.0	.0	.5	.0	.2	1.0
15 Waipahu	1.0	.0	.1	.0	.0	.2	.2	.0	.0	.0	.6	.4	.0	1.7	1.1	1.4	3.0	.0	.0	.0	.0	.0	.0	1.0
16 Mililani	.0	.0	.0	1.7	.0	.0	.0	.3	.0	.0	1.1	1.1	.2	.8	1.9	1.0	1.3	.1	.6	.0	.0	.0	.0	1.0
17 Ewa	.0	.4	.7	.0	.0	.2	.1	.0	.0	.3	.2	.0	.5	.7	1.2	1.7	1.0	1.0	.0	.0	2.2	.0	.6	1.0
18 Waianae	.3	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.1	.0	.1	.0	.0	.9	1.7	.0	.0	.9	.0	.1	1.0
19 NorthShore	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.5	.0	.0	2.5	.0	.0	.0	.0	1.0
20 Koolauloa	.4	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	1.2	.3	.6	.0	1.0
21 Kaneohe	.0	.0	.0	.0	.0	.4	.1	.2	.0	.0	.0	.0	.2	.0	.0	.0	.0	.0	.0	.0	.9	1.4	.0	1.0
22 Kailua	2.2	2.3	.7	.5	.7	.0	.0	.0	.6	.0	1.1	1.4	.0	.0	.0	.0	.0	.0	.0	.0	1.0	1.0	.2	1.0
23 E Honolulu	.9	1.2	.0	1.2	.0	.4	.4	1.3	1.6	.2	.0	.0	.2	.1	.0	.0	.0	.0	.0	.0	.0	.7	1.4	1.0
Totals	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0


TLF, JAW-WB
Observed Mean Trip Time: 5.78 Min
Estimated Mean Trip Time: 5.78 Min
Percent of Trips
35.0%
30.0%
25.0%
20.0%
15.0%
10.0%
5.0%
0.0%
2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32
Off-Peak Time
Observed
Final, -.38,.00540

Estimated Trips
Journey-at-Work Non-Based

Production District	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
1 Downtown	696	65	118	112	21	7	19	17	41	26	115	24	10	6	1	1	0	3	0	0	1	0	0	1283
2 Kakaako	103	34	35	58	12	3	6	4	5	4	16	3	2	0	0	0	0	2	0	0	0	0	0	287
3 Makiki	183	34	111	144	29	9	22	19	15	12	34	14	3	0	0	2	0	1	0	0	0	0	0	632
4 McCully	107	36	67	339	81	15	38	35	10	9	25	11	2	1	0	0	0	5	0	0	0	0	0	781
5 Waikiki	17	6	12	65	88	11	9	9	2	2	5	1	1	1	0	0	0	1	0	0	0	0	0	230
6 Diamond Hd	12	2	8	29	93	88	28	11	1	2	4	1	1	0	0	1	0	1	0	0	0	0	0	282
7 Kaimuki	21	3	12	30	21	25	131	21	3	2	7	4	1	0	0	0	0	1	0	0	0	0	0	282
8 Manoa	27	3	17	42	15	11	24	132	6	3	9	4	2	0	0	0	0	2	0	0	0	0	0	297
9 Nuuanu	44	3	9	8	2	1	3	3	12	4	12	5	2	1	0	0	0	2	0	0	0	0	0	111
10 Kalihi	19	1	5	5	2	0	2	1	3	38	37	16	5	3	0	0	1	1	0	0	1	0	0	140
11 Iwilei	232	20	37	38	10	5	11	11	25	71	467	115	22	9	1	6	0	7	0	0	2	0	0	1089
12 Airport PH	38	4	14	17	5	1	5	4	5	35	130	951	129	78	3	18	0	17	0	0	1	0	0	1455
13 Salt Lake	6	1	2	1	1	1	0	0	1	4	14	19	29	4	1	2	0	2	0	0	1	0	0	89
14 PC Aiea	3	0	0	0	0	0	1	0	1	0	4	73	15	162	10	25	0	16	0	0	0	0	0	310
15 Waipahu	1	0	0	0	0	0	0	0	0	1	1	21	6	37	238	74	5	89	0	0	0	0	0	473
16 Mililani	0	0	0	0	0	0	0	0	0	0	1	4	0	3	6	876	0	9	0	0	0	0	0	899
17 Ewa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	6	0	0	0	0	0	16
18 Waianae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	182	0	0	0	0	0	182
19 NorthShore	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20 Koolauloa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21 Kaneohe	10	1	3	6	2	0	1	1	7	14	21	15	4	2	0	2	0	9	0	0	189	1	0	288
22 Kailua	26	3	4	6	2	1	3	1	20	4	7	6	2	1	0	1	0	9	0	0	17	31	0	144
23 E Honolulu	5	0	3	7	4	8	20	4	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	55
Totals	1550	216	457	907	388	186	323	273	157	232	910	1287	237	309	260	1008	16	365	0	0	212	32	0	9325

Observed Trips
Journey-at-Work Non-Based

Production District	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
	Attraction District																							
1 Downtown	1182	101	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1283
2 Kakaako	84	0	98	0	0	0	0	0	0	0	0	70	0	0	35	0	0	0	0	0	0	0	0	287
3 Makiki	0	98	113	266	0	0	0	0	55	0	83	0	0	0	0	0	0	0	0	0	17	0	0	632
4 McCully	0	15	55	338	100	118	100	0	0	0	0	0	0	0	0	55	0	0	0	0	0	0	0	781
5 Waikiki	0	0	0	0	180	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	230
6 Diamond Hd	0	0	0	59	101	24	0	50	0	0	48	0	0	0	0	0	0	0	0	0	0	0	0	282
7 Kaimuki	0	0	146	0	0	0	68	68	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	282
8 Manoa	0	0	50	59	0	0	0	157	31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	297
9 Nuuanu	111	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	111
10 Kalihi	0	0	0	0	0	0	97	0	43	0	0	0	0	0	0	0	0	0	0	0	0	0	0	140
11 Iwilei	0	0	0	0	0	0	0	0	32	127	682	248	0	0	0	0	0	0	0	0	0	0	0	1089
12 Airport PH	166	0	0	65	0	0	0	0	0	0	99	885	192	48	0	0	0	0	0	0	0	0	0	1455
13 Salt Lake	0	0	0	0	0	0	0	0	0	0	0	0	40	0	49	0	0	0	0	0	0	0	0	89
14 PC Aiea	0	0	0	0	0	0	0	0	0	0	0	48	0	217	0	45	0	0	0	0	0	0	0	310
15 Waipahu	0	0	0	0	0	0	0	0	0	0	0	35	0	49	182	25	0	182	0	0	0	0	0	473
16 Mililani	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	899	0	0	0	0	0	0	0	899
17 Ewa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16	0	0	0	0	0	0	16
18 Waianae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	182	0	0	0	0	0	182
19 NorthShore	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20 Koolauloa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21 Kaneohe	0	0	0	0	0	0	0	0	0	97	0	0	0	0	0	0	0	0	0	0	191	0	0	288
22 Kailua	0	0	0	113	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	31	0	144
23 E Honolulu	0	0	0	0	0	0	55	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	55
Totals	1543	214	462	900	381	192	320	275	161	224	912	1286	232	314	266	1024	16	364	0	0	208	31	0	9325

Estimated Trips - Observed Trips
Journey-at-Work Non-Based

Production District	Attraction District 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
1 Downtown	-486	-36	118	112	21	7	19	17	41	26	115	24	10	6	1	1	0	3	0	0	1	0	0	0
2 Kakaako	19	34	-63	58	12	3	6	4	5	4	16	-67	2	0	-35	0	0	2	0	0	0	0	0	0
3 Makiki	183	-64	-2	-122	29	9	22	19	-40	12	-49	14	3	0	0	2	0	1	0	0	-17	0	0	0
4 McCully	107	21	12	1	-19	-103	-62	35	10	9	25	11	2	1	0	-55	0	5	0	0	0	0	0	0
5 Waikiki	17	6	12	65	-92	-39	9	9	2	2	5	1	1	1	0	0	0	1	0	0	0	0	0	0
6 Diamond Hd	12	2	8	-30	-8	64	28	-39	1	2	-44	1	1	0	0	1	0	1	0	0	0	0	0	0
7 Kaimuki	21	3	-134	30	21	25	63	-47	3	2	7	4	1	0	0	0	0	1	0	0	0	0	0	0
8 Manoa	27	3	-33	-17	15	11	24	-25	-25	3	9	4	2	0	0	0	0	2	0	0	0	0	0	0
9 Nuuanu	-67	3	9	8	2	1	3	3	12	4	12	5	2	1	0	0	0	2	0	0	0	0	0	0
10 Kalihi	19	1	5	5	2	0	-95	1	-40	38	37	16	5	3	0	0	1	1	0	0	1	0	0	0
11 Iwilei	232	20	37	38	10	5	11	11	-7	-56	-215	-133	22	9	1	6	0	7	0	0	2	0	0	0
12 Airport PH	-128	4	14	-48	5	1	5	4	5	35	31	66	-63	30	3	18	0	17	0	0	1	0	0	0
13 Salt Lake	6	1	2	1	1	1	0	0	1	4	14	19	-11	4	-48	2	0	2	0	0	1	0	0	0
14 PC Aiea	3	0	0	0	0	0	1	0	1	0	4	25	15	-55	10	-20	0	16	0	0	0	0	0	0
15 Waipahu	1	0	0	0	0	0	0	0	0	1	1	-14	6	-12	56	49	5	-93	0	0	0	0	0	0
16 Mililani	0	0	0	0	0	0	0	0	0	0	1	4	0	3	6	-23	0	9	0	0	0	0	0	0
17 Ewa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-6	6	0	0	0	0	0	0
18 Waianae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19 NorthShore	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20 Koolauloa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21 Kaneohe	10	1	3	6	2	0	1	1	7	-83	21	15	4	2	0	2	0	9	0	0	-2	1	0	0
22 Kailua	26	3	4	-107	2	1	3	1	20	4	7	6	2	1	0	1	0	9	0	0	17	0	0	0
23 E Honolulu	5	0	3	7	4	8	-35	4	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0
Totals	7	2	-5	7	7	-6	3	-2	-4	8	-2	1	5	-5	-6	-16	0	1	0	0	4	1	0	0

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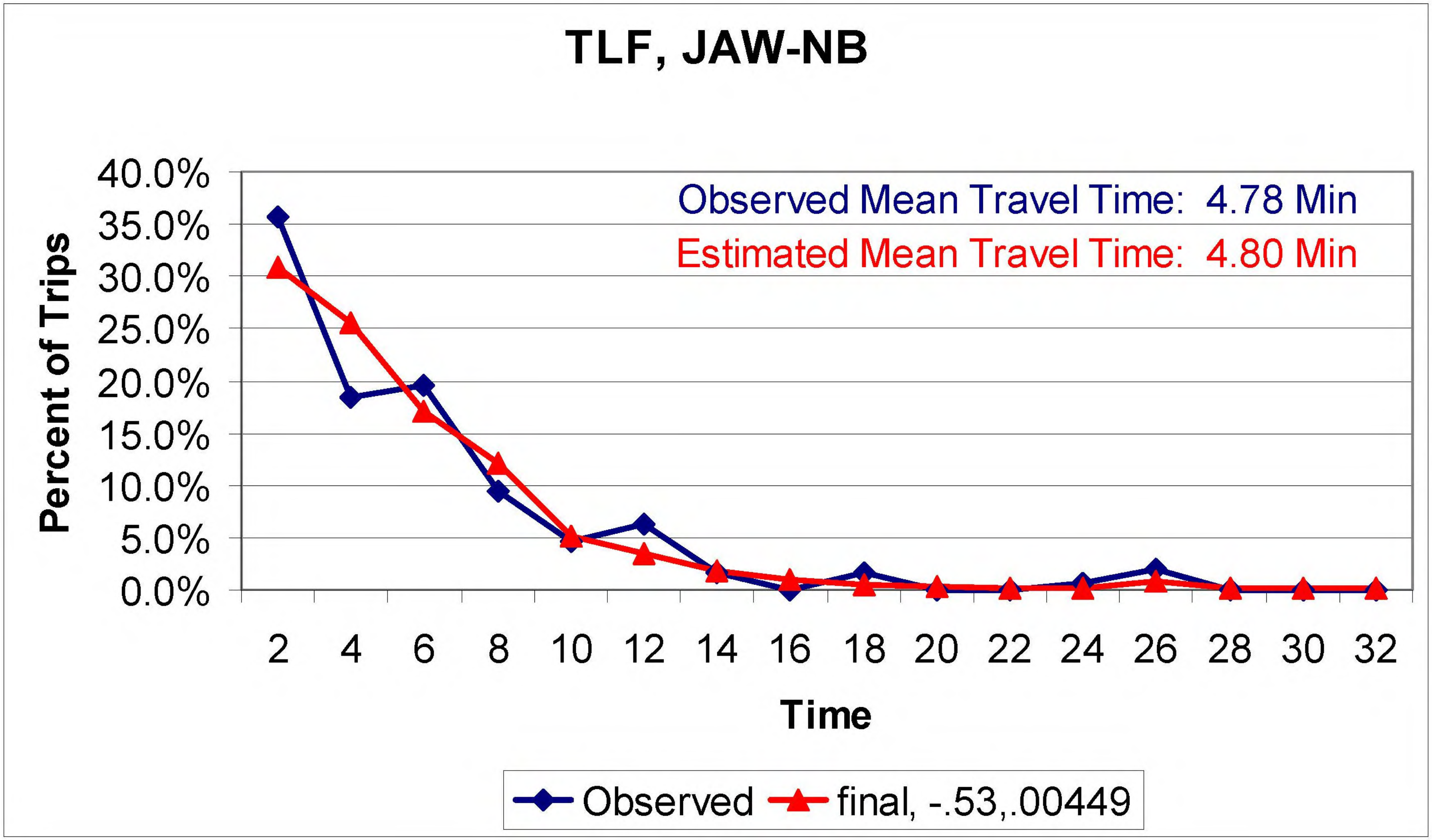
Estimated Trips / Observed Trips
Journey-at-Work Non-Based

Production District	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
1 Downtown	.6	.6	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	1.0
2 Kakaako	1.2	.0	.4	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	1.0
3 Makiki	.0	.3	1.0	.5	.0	.0	.0	.0	.3	.0	.4	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	1.0
4 McCully	.0	2.4	1.2	1.0	.8	.1	.4	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	1.0
5 Waikiki	.0	.0	.0	.0	.5	.2	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	1.0
6 Diamond Hd	.0	.0	.0	.5	.9	3.7	.0	.2	.0	.0	.1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	1.0
7 Kaimuki	.0	.0	.1	.0	.0	.0	1.9	.3	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	1.0
8 Manoa	.0	.0	.3	.7	.0	.0	.0	.8	.2	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	1.0
9 Nuuanu	.4	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	1.0
10 Kalihi	.0	.0	.0	.0	.0	.0	.0	.0	.1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	1.0
11 Iwilei	.0	.0	.0	.0	.0	.0	.0	.0	.8	.6	.7	.5	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	1.0
12 Airport PH	.2	.0	.0	.3	.0	.0	.0	.0	.0	.0	1.3	1.1	.7	1.6	.0	.0	.0	.0	.0	.0	.0	.0	.0	1.0
13 Salt Lake	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.7	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	1.0
14 PC Aiea	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	1.5	.0	.7	.0	.6	.0	.0	.0	.0	.0	.0	.0	1.0
15 Waipahu	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.6	.0	.8	1.3	3.0	.0	.5	.0	.0	.0	.0	.0	1.0
16 Mililani	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	1.0	.0	.0	.0	.0	.0	.0	.0	1.0
17 Ewa	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.6	.0	.0	.0	.0	.0	.0	1.0
18 Waianae	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	1.0	.0	.0	.0	.0	.0	1.0
19 NorthShore	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
20 Koolauloa	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
21 Kaneohe	.0	.0	.0	.0	.0	.0	.0	.0	.0	.1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	1.0	.0	.0	1.0
22 Kailua	.0	.0	.0	.1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	1.0	.0	1.0
23 E Honolulu	.0	.0	.0	.0	.0	.0	.4	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	1.0
Totals	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	.0	.0	1.0	1.0	.0	1.0


TLF, JAW-NB
Observed Mean Travel Time: 4.78 Min
Estimated Mean Travel Time: 4.80 Min
Percent of Trips
40.0%
35.0%
30.0%
25.0%
20.0%
15.0%
10.0%
5.0%
0.0%
2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32
Time
Observed
final, -.53,.00449

AR00076974

Estimated Trips
Non-Work-Related Home-Based School

Production District	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
1 Downtown	237	196	180	84	0	23	18	26	464	88	136	8	28	7	0	0	0	0	0	0	1	2	6	1504
2 Kakaako	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3 Makiki	64	79	1181	351	1	50	34	129	340	16	16	2	8	0	0	1	0	0	0	2	0	0	9	2283
4 McCully	49	101	1058	2600	14	387	205	542	218	17	18	6	6	0	0	0	0	0	0	0	2	0	42	5265
5 Waikiki	33	119	405	859	13	119	52	142	120	10	6	3	5	0	0	0	0	0	0	1	0	0	14	1901
6 Diamond Hd	18	19	477	456	78	1609	511	348	101	13	7	6	4	1	0	1	0	0	0	1	1	2	132	3785
7 Kaimuki	45	53	1298	1073	28	983	2719	1097	301	38	32	10	20	4	1	3	1	4	0	4	1	3	168	7886
8 Manoa	14	23	571	304	3	94	63	2630	229	14	9	3	7	1	0	1	1	1	0	2	0	1	19	3990
9 Nuuanu	239	189	371	129	0	63	44	68	2733	287	778	17	51	6	0	1	2	2	1	1	13	23	15	5033
10 Kalihi	191	153	247	99	0	83	54	63	1243	5978	962	119	424	47	5	4	1	3	0	3	27	11	25	9742
11 Iwilei	292	481	269	133	2	75	62	71	768	1370	2082	138	535	48	3	5	1	1	1	2	9	2	24	6374
12 Airport PH	16	24	37	36	0	26	18	36	58	121	89	3468	1627	104	10	8	0	3	0	7	1	2	8	5699
13 Salt Lake	77	81	248	196	7	112	74	155	278	452	289	1901	7869	1194	52	56	17	14	1	17	13	10	40	13153
14 PC Aiea	46	96	291	224	8	143	92	204	198	215	443	1344	1987	8471	829	335	86	55	4	67	24	29	73	15264
15 Waipahu	31	66	136	128	6	83	54	118	134	109	82	525	315	2345	5817	1444	1188	46	5	49	17	21	47	12766
16 Mililani	28	81	237	167	6	122	74	172	166	79	53	229	177	381	614	20179	90	73	41	100	26	47	88	23230
17 Ewa	28	76	210	159	5	114	68	167	162	82	58	259	167	1729	1240	290	9810	152	9	88	26	42	80	15021
18 Waianae	11	34	100	73	3	52	30	77	69	22	15	31	38	27	10	29	21	9998	5	43	13	19	40	10760
19 NorthShore	14	42	132	90	5	69	39	96	88	33	14	44	52	30	9	266	16	43	2021	546	16	25	52	3742
20 Koolauloa	4	13	38	29	2	17	11	31	27	9	3	13	16	7	3	13	3	13	7	5679	7	7	16	5968
21 Kaneohe	76	136	313	186	71	129	78	166	615	412	173	111	186	60	10	58	24	63	9	134	10781	1792	76	15659
22 Kailua	33	56	132	76	4	50	27	67	290	46	25	25	35	19	5	21	12	28	3	27	427	7983	86	9477
23 E Honolulu	36	61	686	487	18	746	838	469	240	45	33	43	52	26	10	34	12	40	5	50	19	65	7593	11608
Totals	1582	2179	8617	7939	274	5149	5165	6874	8842	9456	5323	8305	13609	14507	8618	22749	11285	10539	2112	6823	11424	10086	8653	190110

Observed Trips
Non-Work-Related Home-Based School

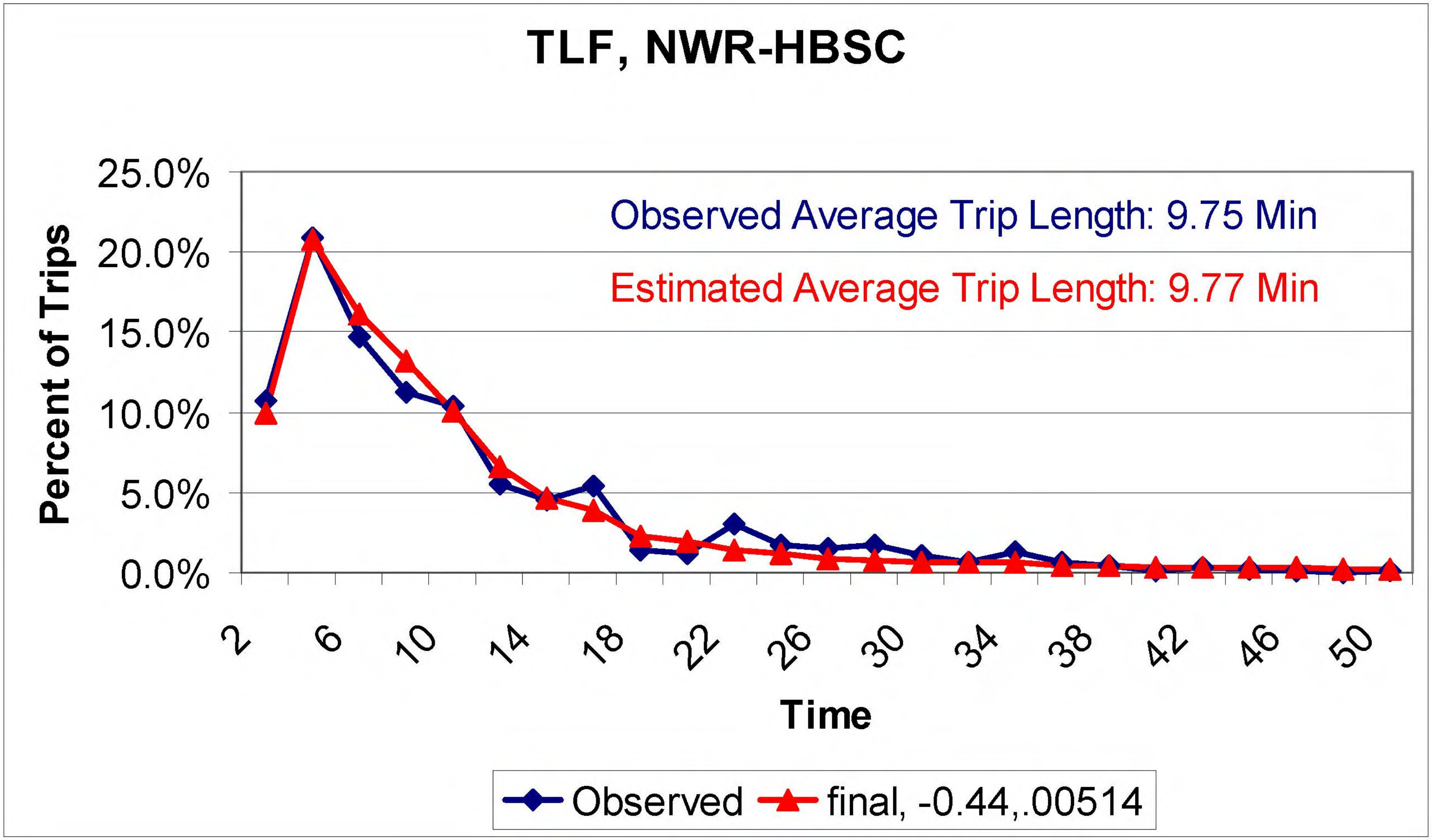
Production District	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
1 Downtown	428	222	106	0	0	0	241	129	327	51	0	0	0	0	0	0	0	0	0	0	0	0	0	1504
2 Kakaako	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3 Makiki	0	0	1237	450	0	0	157	132	111	156	0	0	0	0	0	0	0	0	0	0	0	0	40	2283
4 McCully	0	128	225	3507	0	468	505	159	115	0	0	0	59	0	0	0	0	0	99	0	0	0	0	5265
5 Waikiki	0	149	0	385	0	317	161	0	0	0	0	222	667	0	0	0	0	0	0	0	0	0	0	1901
6 Diamond Hd	0	0	504	48	168	1880	350	0	330	147	0	0	0	0	0	0	0	0	0	0	0	0	358	3785
7 Kaimuki	0	0	1191	632	0	1453	1975	1319	779	335	0	0	0	0	0	0	0	0	0	0	0	0	202	7886
8 Manoa	0	0	224	604	48	0	0	2526	588	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3990
9 Nuuanu	288	175	945	937	0	0	0	95	2080	79	0	128	0	0	79	0	0	0	0	0	0	107	120	5033
10 Kalihi	124	406	0	0	0	0	297	0	1812	4314	2756	0	0	33	0	0	0	0	0	0	0	0	0	9742
11 Iwilei	158	520	144	0	0	0	58	0	321	1956	2029	0	170	0	0	53	0	0	0	0	214	751	0	6374
12 Airport PH	0	0	0	0	0	0	0	0	0	0	0	3747	1952	0	0	0	0	0	0	0	0	0	0	5699
13 Salt Lake	0	0	118	0	0	0	164	223	771	0	0	2239	9486	152	0	0	0	0	0	0	0	0	0	13153
14 PC Aiea	130	0	565	0	0	190	0	497	312	993	0	1054	775	9363	639	547	199	0	0	0	0	0	0	15264
15 Waipahu	0	94	161	0	0	0	268	0	151	188	0	0	209	3338	7673	378	306	0	0	0	0	0	0	12766
16 Mililani	0	129	402	174	0	0	0	161	288	0	419	0	0	0	832	1108	466	0	0	0	0	0	0	23230
17 Ewa	178	340	119	0	0	0	0	847	119	113	113	709	290	1622	118	360	10093	0	0	0	0	0	0	15021
18 Waianae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	205	10555	0	0	0	0	0	10760
19 NorthShore	0	0	376	0	0	0	0	0	0	133	0	0	0	0	0	291	0	0	2019	923	0	0	0	3742
20 Koolauloa	0	0	0	0	0	0	0	0	0	62	0	0	0	0	0	0	0	0	0	5906	0	0	0	5968
21 Kaneohe	111	0	777	125	0	0	458	444	451	529	0	58	0	0	0	0	0	0	0	0	10949	1757	0	15659
22 Kailua	37	0	489	118	0	273	212	186	218	102	0	91	0	0	0	0	0	0	0	0	269	7482	0	9477
23 E Honolulu	135	0	1043	957	65	567	322	145	80	307	0	52	0	0	0	0	0	0	0	0	0	0	7935	11608
Totals	1589	2163	8626	7937	281	5148	5168	6863	8853	9465	5317	8300	13608	14508	8592	22737	11269	10555	2118	6829	11432	10097	8655	190110

Estimated Trips - Observed Trips
Non-Work-Related Home-Based School

Production District	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
1 Downtown	-191	-26	74	84	0	23	-223	-103	137	37	136	8	28	7	0	0	0	0	0	0	1	2	6	0
2 Kakaako	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3 Makiki	64	79	-56	-99	1	50	-123	-3	229	-140	16	2	8	0	0	1	0	0	0	2	0	0	-31	0
4 McCully	49	-27	833	-907	14	-81	-300	383	103	17	18	6	-53	0	0	0	0	0	-99	0	2	0	42	0
5 Waikiki	33	-30	405	474	13	-198	-109	142	120	10	6	-219	-662	0	0	0	0	0	0	1	0	0	14	0
6 Diamond Hd	18	19	-27	408	-90	-271	161	348	-229	-134	7	6	4	1	0	1	0	0	0	1	1	2	-226	0
7 Kaimuki	45	53	107	441	28	-470	744	-222	-478	-297	32	10	20	4	1	3	1	4	0	4	1	3	-34	0
8 Manoa	14	23	347	-300	-45	94	63	104	-359	14	9	3	7	1	0	1	1	1	0	2	0	1	19	0
9 Nuuanu	-49	14	-574	-808	0	63	44	-27	653	208	778	-111	51	6	-79	1	2	2	1	1	13	-84	-105	0
10 Kalihi	67	-253	247	99	0	83	-243	63	-569	1664	-1794	119	424	14	5	4	1	3	0	3	27	11	25	0
11 Iwilei	134	-39	125	133	2	75	4	71	447	-586	53	138	365	48	3	-48	1	1	1	2	-205	-749	24	0
12 Airport PH	16	24	37	36	0	26	18	36	58	121	89	-279	-325	104	10	8	0	3	0	7	1	2	8	0
13 Salt Lake	77	81	130	196	7	112	-90	-68	-493	452	289	-338	-1617	1042	52	56	17	14	1	17	13	10	40	0
14 PC Aiea	-84	96	-274	224	8	-47	92	-293	-114	-778	443	290	1212	-892	190	-212	-113	55	4	67	24	29	73	0
15 Waipahu	31	-28	-25	128	6	83	-214	118	-17	-79	82	525	106	-993	-1856	1066	882	46	5	49	17	21	47	0
16 Mililani	28	-48	-165	-7	6	122	74	11	-122	79	-366	229	177	381	531	-929	-376	73	41	100	26	47	88	0
17 Ewa	-150	-264	91	159	5	114	68	-680	43	-31	-55	-450	-123	107	1122	-70	-283	152	9	88	26	42	80	0
18 Waianae	11	34	100	73	3	52	30	77	69	22	15	31	38	27	10	29	-184	-557	5	43	13	19	40	0
19 NorthShore	14	42	-244	90	5	69	39	96	88	-100	14	44	52	30	9	-25	16	43	2	-377	16	25	52	0
20 Koolauloa	4	13	38	29	2	17	11	31	27	-53	3	13	16	7	3	13	3	13	7	-227	7	7	16	0
21 Kaneohe	-35	136	-464	61	71	129	-380	-278	164	-117	173	53	186	60	10	58	24	63	9	134	-168	35	76	0
22 Kailua	-4	56	-357	-42	4	-223	-185	-119	72	-56	25	-66	35	19	5	21	12	28	3	27	158	501	86	0
23 E Honolulu	-99	61	-357	-470	-47	179	516	324	160	-262	33	-9	52	26	10	34	12	40	5	50	19	65	-342	0
Totals	-7	16	-9	2	-7	1	-3	11	-11	-9	6	5	1	-1	26	12	16	-16	-6	-6	-8	-11	-2	0

Estimated Trips / Observed Trips
Non-Work-Related Home-Based School

Production District	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
1 Downtown	.6	.9	1.7	.0	.0	.0	.1	.2	1.4	1.7	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	1.0
2 Kakaako	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
3 Makiki	.0	.0	1.0	.8	.0	.0	.2	1.0	3.1	.1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.2	1.0
4 McCully	.0	.8	4.7	.7	.0	.8	.4	3.4	1.9	.0	.0	.0	.1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	1.0
5 Waikiki	.0	.8	.0	2.2	.0	.4	.3	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	1.0
6 Diamond Hd	.0	.0	.9	9.5	.5	.9	1.5	.0	.3	.1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.4	1.0
7 Kaimuki	.0	.0	1.1	1.7	.0	.7	1.4	.8	.4	.1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.8	1.0
8 Manoa	.0	.0	2.5	.5	.1	.0	.0	1.0	.4	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	1.0
9 Nuuanu	.8	1.1	.4	.1	.0	.0	.0	.7	1.3	3.6	.0	.1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.2	.1	1.0
10 Kalihi	1.5	.4	.0	.0	.0	.0	.2	.0	.7	1.4	.3	.0	.0	1.4	.0	.0	.0	.0	.0	.0	.0	.0	.0	1.0
11 Iwilei	1.8	.9	1.9	.0	.0	.0	1.1	.0	2.4	.7	1.0	.0	3.1	.0	.0	.1	.0	.0	.0	.0	.0	.0	.0	1.0
12 Airport PH	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.9	.8	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	1.0
13 Salt Lake	.0	.0	2.1	.0	.0	.0	.5	.7	.4	.0	.0	.8	.8	7.9	.0	.0	.0	.0	.0	.0	.0	.0	.0	1.0
14 PC Aiea	.4	.0	.5	.0	.0	.8	.0	.4	.6	.2	.0	1.3	2.6	.9	1.3	.6	.4	.0	.0	.0	.0	.0	.0	1.0
15 Waipahu	.0	.7	.8	.0	.0	.0	.2	.0	.9	.6	.0	.0	1.5	.7	.8	3.8	3.9	.0	.0	.0	.0	.0	.0	1.0
16 Mililani	.0	.6	.6	1.0	.0	.0	.0	1.1	.6	.0	.1	.0	.0	.0	7.4	1.0	.2	.0	.0	.0	.0	.0	.0	1.0
17 Ewa	.2	.2	1.8	.0	.0	.0	.0	.2	1.4	.7	.5	.4	.6	1.1	10.5	.8	1.0	.0	.0	.0	.0	.0	.0	1.0
18 Waianae	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.1	.9	.0	.0	.0	.0	.0	1.0
19 NorthShore	.0	.0	.4	.0	.0	.0	.0	.0	.0	.2	.0	.0	.0	.0	.0	.9	.0	.0	1.0	.6	.0	.0	.0	1.0
20 Koolauloa	.0	.0	.0	.0	.0	.0	.0	.0	.0	.1	.0	.0	.0	.0	.0	.0	.0	.0	.0	1.0	.0	.0	.0	1.0
21 Kaneohe	.7	.0	.4	1.5	.0	.0	.2	.4	1.4	.8	.0	1.9	.0	.0	.0	.0	.0	.0	.0	.0	1.0	1.0	.0	1.0
22 Kailua	.9	.0	.3	.6	.0	.2	.1	.4	1.3	.5	.0	.3	.0	.0	.0	.0	.0	.0	.0	.0	1.6	1.1	.0	1.0
23 E Honolulu	.3	.0	.7	.5	.3	1.3	2.6	3.2	3.0	.1	.0	.8	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	1.0	1.0
Totals	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0



TLF, NWR-HBSC
Observed Average Trip Length: 9.75 Min
Estimated Average Trip Length: 9.77 Min
Percent of Trips
25.0%
20.0%
15.0%
10.0%
5.0%
0.0%
2
6
10
14
18
22
26
30
34
38
42
46
50
Time
Observed
final, -0.44,.00514

AR00076979

Estimated Trips
Non-Work-Related Home-Based College All-Veh

Production District	Attraction District 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
1 Downtown	551	0	4	20	0	60	4	200	1	0	33	1	0	3	25	0	0	0	1	1	4	5	0	913
2 Kakaako	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3 Makiki	552	0	88	176	0	1013	42	3579	18	0	198	9	10	16	252	0	0	0	16	5	54	61	0	6089
4 McCully	448	0	61	251	0	728	46	3479	7	0	98	7	4	11	116	0	0	0	5	4	21	29	0	5315
5 Waikiki	112	0	35	107	0	534	30	1101	0	0	45	6	0	7	23	0	0	0	0	0	8	4	0	2012
6 Diamond Hd	57	0	16	24	0	655	17	1386	9	0	38	2	4	2	90	0	0	0	7	1	17	23	0	2348
7 Kaimuki	63	0	11	21	0	462	14	1370	10	0	37	1	5	1	92	0	0	0	7	3	18	24	0	2139
8 Manoa	69	0	16	30	0	388	11	1658	9	0	40	1	3	1	88	0	0	0	8	2	16	22	0	2362
9 Nuuanu	148	0	7	16	0	178	4	497	11	0	49	0	5	2	101	0	0	0	7	3	21	35	0	1084
10 Kalihi	138	0	10	26	0	220	9	559	6	0	102	7	4	13	119	0	0	0	6	3	36	27	0	1285
11 Iwilei	67	0	6	15	0	86	5	204	1	0	64	4	1	8	34	0	0	0	1	0	9	5	0	510
12 Airport PH	54	0	5	17	0	138	7	369	1	0	50	17	3	23	113	0	0	0	4	0	14	8	0	823
13 Salt Lake	70	0	6	18	0	221	9	612	6	0	72	10	9	12	253	0	0	0	16	1	28	22	0	1365
14 PC Aiea	132	0	17	33	0	606	18	1680	16	0	135	11	37	74	2046	1	0	0	112	11	67	66	0	5062
15 Waipahu	41	0	4	12	0	159	4	431	6	0	41	3	7	22	700	0	0	0	29	2	18	15	0	1494
16 Mililani	27	0	3	7	0	129	3	364	6	0	29	1	7	2	553	0	0	0	79	7	15	15	0	1247
17 Ewa	95	0	13	24	0	409	11	1107	13	0	95	6	19	22	1405	1	0	0	109	8	46	44	0	3427
18 Waianae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19 NorthShore	22	0	3	11	0	81	4	188	1	0	15	1	2	8	113	1	0	0	137	7	8	5	0	607
20 Koolauloa	44	0	6	18	0	144	8	315	3	0	28	3	2	15	74	0	0	0	50	490	44	20	0	1264
21 Kaneohe	98	0	12	22	0	285	11	738	11	0	73	3	10	8	206	0	0	0	14	24	254	193	0	1962
22 Kailua	60	0	5	13	0	82	3	291	6	0	32	2	2	5	61	0	0	0	4	3	68	90	0	727
23 E Honolulu	37	0	9	16	0	353	8	858	6	0	28	0	5	4	67	0	0	0	5	4	20	28	0	1448
Totals	2885	0	337	877	0	6931	268	20986	147	0	1302	95	139	259	6531	3	0	0	617	579	786	741	0	43483

Observed Trips
Non-Work-Related Home-Based College All-Veh

Production District	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
	Attraction District																							
1 Downtown	488	0	0	0	0	0	0	425	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	913
2 Kakaako	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3 Makiki	355	0	247	0	0	1505	0	3982	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6089
4 McCully	606	0	0	164	0	952	0	3387	0	0	206	0	0	0	0	0	0	0	0	0	0	0	0	5315
5 Waikiki	959	0	0	0	0	112	0	941	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2012
6 Diamond Hd	0	0	0	0	0	653	0	1425	0	0	0	0	129	0	0	0	0	0	0	0	141	0	0	2348
7 Kaimuki	0	0	0	105	0	725	0	646	0	0	44	0	0	0	0	0	0	0	619	0	0	0	0	2139
8 Manoa	0	0	0	0	0	0	0	2362	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2362
9 Nuuanu	40	0	0	0	0	180	0	751	0	0	34	0	0	0	79	0	0	0	0	0	0	0	0	1084
10 Kalihi	101	0	0	0	0	623	0	274	0	0	153	0	0	0	134	0	0	0	0	0	0	0	0	1285
11 Iwilei	58	0	0	0	0	380	0	0	0	0	72	0	0	0	0	0	0	0	0	0	0	0	0	510
12 Airport PH	0	0	0	0	0	263	0	160	0	0	225	91	0	0	84	0	0	0	0	0	0	0	0	823
13 Salt Lake	0	0	0	0	0	0	201	979	0	0	52	0	0	0	133	0	0	0	0	0	0	0	0	1365
14 PC Aiea	54	0	0	0	0	605	0	2163	132	0	224	0	0	267	1617	0	0	0	0	0	0	0	0	5062
15 Waipahu	0	0	0	259	0	0	0	328	0	0	0	0	0	0	907	0	0	0	0	0	0	0	0	1494
16 Mililani	0	0	0	0	0	0	0	190	0	0	0	0	0	0	1051	6	0	0	0	0	0	0	0	1247
17 Ewa	175	0	0	0	0	0	0	654	0	0	0	0	0	0	1944	0	0	0	0	0	0	654	0	3427
18 Waianae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19 NorthShore	0	0	0	211	0	0	0	158	0	0	0	0	0	0	238	0	0	0	0	0	0	0	0	607
20 Koolauloa	0	0	0	0	0	187	0	310	0	0	179	0	0	0	0	0	0	0	0	588	0	0	0	1264
21 Kaneohe	0	0	96	0	0	220	0	1102	0	0	125	0	0	0	269	0	0	0	0	0	150	0	0	1962
22 Kailua	56	0	0	0	0	67	0	259	0	0	0	0	0	0	0	0	0	0	0	0	345	0	0	727
23 E Honolulu	0	0	0	132	0	457	71	473	0	0	0	0	0	0	78	0	0	0	0	0	157	80	0	1448
Totals	2892	0	343	871	0	6929	272	20969	132	0	1314	91	129	267	6534	6	0	0	619	588	793	734	0	43483

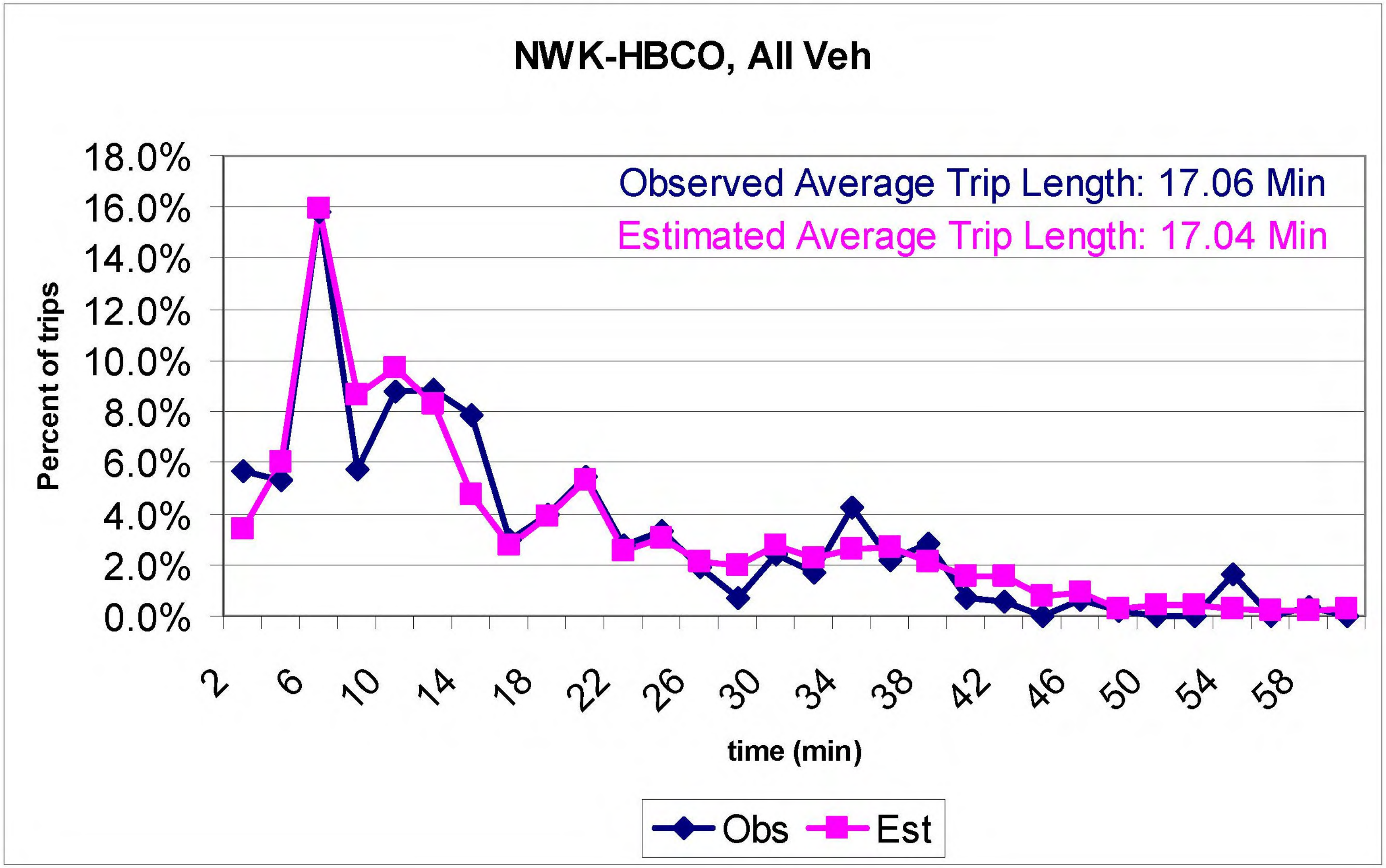
Estimated Trips - Observed Trips
Non-Work-Related Home-Based College All-Veh

Production District	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
1 Downtown	63	0	4	20	0	60	4	-225	1	0	33	1	0	3	25	0	0	0	1	1	4	5	0	0
2 Kakaako	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3 Makiki	197	0	-159	176	0	-492	42	-403	18	0	198	9	10	16	252	0	0	0	16	5	54	61	0	0
4 McCully	-158	0	61	87	0	-224	46	92	7	0	-108	7	4	11	116	0	0	0	5	4	21	29	0	0
5 Waikiki	-847	0	35	107	0	422	30	160	0	0	45	6	0	7	23	0	0	0	0	0	8	4	0	0
6 Diamond Hd	57	0	16	24	0	2	17	-39	9	0	38	2	-125	2	90	0	0	0	7	1	-124	23	0	0
7 Kaimuki	63	0	11	-84	0	-263	14	724	10	0	-7	1	5	1	92	0	0	0	-612	3	18	24	0	0
8 Manoa	69	0	16	30	0	388	11	-704	9	0	40	1	3	1	88	0	0	0	8	2	16	22	0	0
9 Nuuanu	108	0	7	16	0	-2	4	-254	11	0	15	0	5	2	22	0	0	0	7	3	21	35	0	0
10 Kalihi	37	0	10	26	0	-403	9	285	6	0	-51	7	4	13	-15	0	0	0	6	3	36	27	0	0
11 Iwilei	9	0	6	15	0	-294	5	204	1	0	-8	4	1	8	34	0	0	0	1	0	9	5	0	0
12 Airport PH	54	0	5	17	0	-125	7	209	1	0	-175	-74	3	23	29	0	0	0	4	0	14	8	0	0
13 Salt Lake	70	0	6	18	0	221	-192	-367	6	0	20	10	9	12	120	0	0	0	16	1	28	22	0	0
14 PC Aiea	78	0	17	33	0	1	18	-483	-116	0	-89	11	37	-193	429	1	0	0	112	11	67	66	0	0
15 Waipahu	41	0	4	-247	0	159	4	103	6	0	41	3	7	22	-207	0	0	0	29	2	18	15	0	0
16 Mililani	27	0	3	7	0	129	3	174	6	0	29	1	7	2	-498	-6	0	0	79	7	15	15	0	0
17 Ewa	-80	0	13	24	0	409	11	453	13	0	95	6	19	22	-539	1	0	0	109	8	46	-610	0	0
18 Waianae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19 NorthShore	22	0	3	-200	0	81	4	30	1	0	15	1	2	8	-125	1	0	0	137	7	8	5	0	0
20 Koolauloa	44	0	6	18	0	-43	8	5	3	0	-151	3	2	15	74	0	0	0	50	-98	44	20	0	0
21 Kaneohe	98	0	-84	22	0	65	11	-364	11	0	-52	3	10	8	-63	0	0	0	14	24	104	193	0	0
22 Kailua	4	0	5	13	0	15	3	32	6	0	32	2	2	5	61	0	0	0	4	3	-277	90	0	0
23 E Honolulu	37	0	9	-116	0	-104	-63	385	6	0	28	0	5	4	-11	0	0	0	5	4	-137	-52	0	0
Totals	-7	0	-6	6	0	2	-4	17	15	0	-12	4	10	-8	-3	-3	0	0	-2	-9	-7	7	0	0

AR00076982

Estimated Trips / Observed Trips
Non-Work-Related Home-Based College All-Veh

Production District	Attraction District 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
1 Downtown	1.1	.0	.0	.0	.0	.0	.0	.5	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	1.0
2 Kakaako	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
3 Makiki	1.6	.0	.4	.0	.0	.7	.0	.9	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	1.0
4 McCully	.7	.0	.0	1.5	.0	.8	.0	1.0	.0	.0	.5	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	1.0
5 Waikiki	.1	.0	.0	.0	.0	4.8	.0	1.2	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	1.0
6 Diamond Hd	.0	.0	.0	.0	.0	1.0	.0	1.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.1	.0	.0	1.0
7 Kaimuki	.0	.0	.0	.2	.0	.6	.0	2.1	.0	.0	.8	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	1.0
8 Manoa	.0	.0	.0	.0	.0	.0	.0	.7	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	1.0
9 Nuuanu	3.7	.0	.0	.0	.0	1.0	.0	.7	.0	.0	1.4	.0	.0	.0	1.3	.0	.0	.0	.0	.0	.0	.0	.0	1.0
10 Kalihi	1.4	.0	.0	.0	.0	.4	.0	2.0	.0	.0	.7	.0	.0	.0	.9	.0	.0	.0	.0	.0	.0	.0	.0	1.0
11 Iwilei	1.2	.0	.0	.0	.0	.2	.0	.0	.0	.0	.9	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	1.0
12 Airport PH	.0	.0	.0	.0	.0	.5	.0	2.3	.0	.0	.2	.2	.0	.0	1.3	.0	.0	.0	.0	.0	.0	.0	.0	1.0
13 Salt Lake	.0	.0	.0	.0	.0	.0	.0	.6	.0	.0	1.4	.0	.0	.0	1.9	.0	.0	.0	.0	.0	.0	.0	.0	1.0
14 PC Aiea	2.4	.0	.0	.0	.0	1.0	.0	.8	.1	.0	.6	.0	.0	.3	1.3	.0	.0	.0	.0	.0	.0	.0	.0	1.0
15 Waipahu	.0	.0	.0	.0	.0	.0	.0	1.3	.0	.0	.0	.0	.0	.0	.8	.0	.0	.0	.0	.0	.0	.0	.0	1.0
16 Mililani	.0	.0	.0	.0	.0	.0	.0	1.9	.0	.0	.0	.0	.0	.0	.5	.0	.0	.0	.0	.0	.0	.0	.0	1.0
17 Ewa	.5	.0	.0	.0	.0	.0	.0	1.7	.0	.0	.0	.0	.0	.0	.7	.0	.0	.0	.0	.0	.0	.1	.0	1.0
18 Waianae	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
19 NorthShore	.0	.0	.0	.1	.0	.0	.0	1.2	.0	.0	.0	.0	.0	.0	.5	.0	.0	.0	.0	.0	.0	.0	.0	1.0
20 Koolauloa	.0	.0	.0	.0	.0	.8	.0	1.0	.0	.0	.2	.0	.0	.0	.0	.0	.0	.0	.0	.8	.0	.0	.0	1.0
21 Kaneohe	.0	.0	.1	.0	.0	1.3	.0	.7	.0	.0	.6	.0	.0	.0	.8	.0	.0	.0	.0	.0	1.7	.0	.0	1.0
22 Kailua	1.1	.0	.0	.0	.0	1.2	.0	1.1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.2	.0	.0	1.0
23 E Honolulu	.0	.0	.0	.1	.0	.8	.1	1.8	.0	.0	.0	.0	.0	.0	.9	.0	.0	.0	.0	.0	.1	.3	.0	1.0
Totals	1.0	.0	1.0	1.0	.0	1.0	1.0	1.0	1.1	.0	1.0	1.0	1.1	1.0	1.0	.5	.0	.0	1.0	1.0	1.0	1.0	.0	1.0


NWK-HBCO, All Veh
Observed Average Trip Length: 17.06 Min
Estimated Average Trip Length: 17.04 Min
Percent of trips
18.0%
16.0%
14.0%
12.0%
10.0%
8.0%
6.0%
4.0%
2.0%
0.0%
2
6
10
14
18
22
26
30
34
38
42
46
50
54
58
time (min)
Obs
Est

Estimated Trips
Non-Work-Related Home-Based Shopping All-Veh

Production District	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
	Attraction District																							
1 Downtown	1109	217	138	388	1	47	38	25	32	70	202	85	21	34	9	4	1	0	0	0	7	4	13	2445
2 Kakaako	326	490	297	717	9	96	69	23	28	29	134	49	9	31	4	3	0	0	0	0	9	6	20	2349
3 Makiki	1078	845	2724	2745	23	384	292	276	104	180	397	264	59	124	29	13	0	0	0	0	34	17	87	9675
4 McCully	503	624	894	4569	52	633	512	263	46	91	187	145	36	63	20	6	1	0	0	1	18	8	123	8795
5 Waikiki	571	887	924	6723	349	549	546	173	34	65	164	140	24	53	13	9	1	2	1	0	14	10	96	11348
6 Diamond Hd	199	138	351	1126	33	1711	1584	161	43	67	175	114	25	70	15	2	1	1	1	1	24	11	320	6173
7 Kaimuki	392	304	579	1909	16	2365	1655	308	56	118	262	228	48	116	28	20	1	1	0	2	34	21	397	8860
8 Manoa	127	86	290	726	16	315	218	644	32	51	138	89	18	56	15	1	0	0	0	0	19	10	71	2922
9 Nuuanu	776	256	426	991	12	276	202	104	219	290	641	330	75	195	35	10	1	0	0	0	102	62	64	5067
10 Kalihi	580	170	274	605	7	175	124	55	116	1593	1262	706	166	393	75	16	3	0	0	1	210	23	46	6600
11 Iwilei	716	95	96	206	1	57	38	19	50	154	745	243	53	110	21	6	0	0	0	0	29	3	16	2658
12 Airport PH	93	46	67	165	2	46	31	17	17	103	324	3166	370	560	98	28	3	0	0	0	26	6	12	5180
13 Salt Lake	292	155	208	538	2	130	93	48	49	315	714	3752	2416	1684	300	83	14	0	1	2	74	10	45	10925
14 PC Aiea	204	95	184	409	5	141	99	38	65	251	546	3052	596	10847	1985	354	88	0	0	1	98	15	36	19109
15 Waipahu	41	15	30	67	1	23	17	8	10	35	96	838	87	2739	6231	772	261	2	3	0	21	3	6	11306
16 Mililani	84	20	40	95	3	27	22	15	10	31	90	840	71	3154	2867	10274	83	10	38	2	19	15	11	17821
17 Ewa	46	27	33	90	1	21	13	17	3	27	64	518	57	1355	2884	344	1876	12	5	8	20	13	19	7453
18 Waianae	59	45	32	135	1	31	21	24	3	24	52	407	45	468	612	250	383	5035	10	24	33	31	51	7776
19 NorthShore	9	9	12	30	0	8	6	5	0	8	15	91	8	147	160	1198	10	2	973	48	9	7	13	2768
20 Koolauloa	14	10	8	29	0	7	5	7	2	4	9	69	7	25	14	30	6	2	57	3871	20	9	14	4219
21 Kaneohe	121	67	94	223	2	73	43	26	40	139	252	246	52	144	33	23	5	0	0	2	8658	1169	27	11439
22 Kailua	149	76	89	228	2	86	56	19	53	61	149	127	26	76	17	11	4	1	0	2	1724	8886	80	11922
23 E Honolulu	142	100	270	726	15	2021	547	132	40	56	152	118	30	72	19	14	1	0	0	1	46	95	7561	12158
Totals	7631	4777	8060	23440	553	9222	6231	2407	1052	3762	6770	15617	4299	22516	15484	13471	2743	5068	1089	3966	11248	10434	9128	188968

Observed Trips
Non-Work-Related Home-Based Shopping All-Veh

Production District	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
1 Downtown	1603	0	0	433	0	258	0	0	0	0	95	0	56	0	0	0	0	0	0	0	0	0	0	2445
2 Kakaako	0	784	276	560	0	0	0	0	0	0	330	399	0	0	0	0	0	0	0	0	0	0	0	2349
3 Makiki	632	683	3973	2136	83	204	91	732	0	0	441	126	0	410	45	0	0	0	0	0	0	0	119	9675
4 McCully	455	1384	253	5168	0	459	0	103	0	0	575	0	0	199	199	0	0	0	0	0	0	0	0	8795
5 Waikiki	150	127	1477	7646	381	566	129	205	0	0	0	156	0	0	309	62	0	0	0	0	0	0	140	11348
6 Diamond Hd	0	243	0	1030	0	1971	2204	0	0	0	144	426	0	155	0	0	0	0	0	0	0	0	0	6173
7 Kaimuki	608	1183	280	726	0	3039	2586	78	0	124	61	0	0	0	0	0	0	0	0	0	0	0	175	8860
8 Manoa	112	134	791	189	48	118	107	1149	0	61	0	213	0	0	0	0	0	0	0	0	0	0	0	2922
9 Nuuanu	1666	26	319	1028	0	29	0	73	864	85	601	0	0	94	0	0	0	0	0	0	23	0	259	5067
10 Kalihi	637	30	324	413	0	46	0	0	87	2747	1788	280	0	96	89	63	0	0	0	0	0	0	0	6600
11 Iwilei	818	0	0	285	0	0	0	0	0	0	1086	80	117	0	0	0	0	0	0	0	0	272	0	2658
12 Airport PH	0	0	0	0	0	0	0	0	0	0	0	3785	81	1224	0	0	0	0	0	0	90	0	0	5180
13 Salt Lake	0	0	133	428	0	295	0	0	0	162	465	3718	3773	639	1092	220	0	0	0	0	0	0	0	10925
14 PC Aiea	393	0	0	1076	0	0	469	0	104	521	1003	2530	0	12669	169	0	175	0	0	0	0	0	0	19109
15 Waipahu	0	0	0	0	0	0	0	0	0	0	0	118	214	2213	8501	260	0	0	0	0	0	0	0	11306
16 Mililani	228	0	99	304	0	0	76	0	0	0	114	1056	0	3503	1914	10162	0	365	0	0	0	0	0	17821
17 Ewa	134	0	0	211	0	0	0	0	0	0	0	1521	0	192	2779	383	2233	0	0	0	0	0	0	7453
18 Waianae	0	75	0	776	0	0	0	0	0	0	0	247	0	617	0	1020	333	4708	0	0	0	0	0	7776
19 NorthShore	0	0	0	40	0	0	0	0	0	0	0	77	0	527	0	1107	0	0	1017	0	0	0	0	2768
20 Koolauloa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	140	0	0	0	75	3947	57	0	0	4219
21 Kaneohe	45	0	0	131	0	0	0	0	0	56	56	747	65	0	154	188	0	0	0	0	8950	876	171	11439
22 Kailua	0	35	0	218	42	0	35	0	0	0	0	133	0	0	109	0	0	0	0	0	1869	9170	311	11922
23 E Honolulu	160	77	138	647	0	2212	519	86	0	0	0	0	0	0	0	0	0	0	0	0	257	119	7943	12158
Totals	7641	4781	8063	23445	554	9197	6216	2426	1055	3756	6759	15612	4306	22538	15500	13465	2741	5073	1092	3947	11246	10437	9118	188968

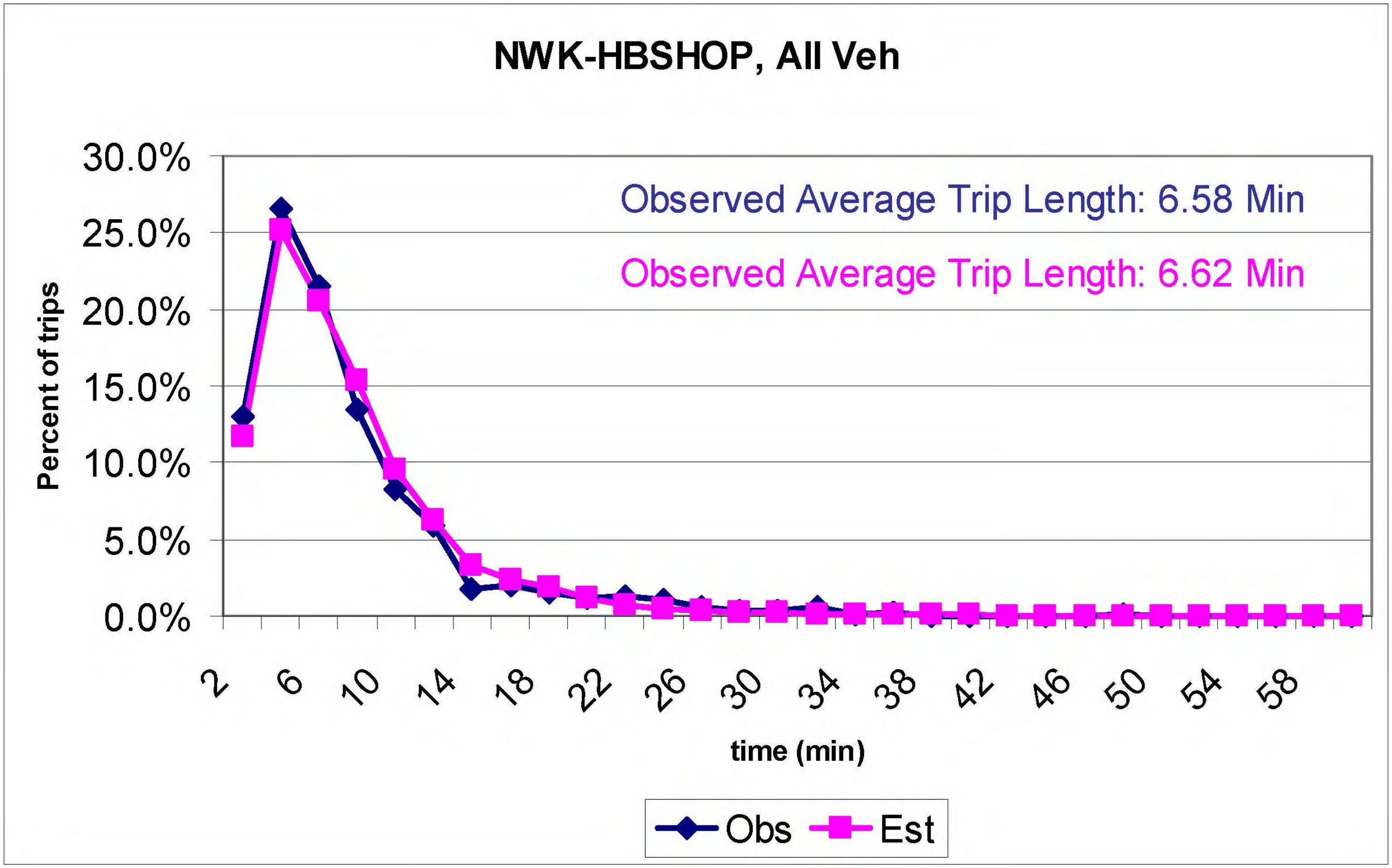
AR00076986

Estimated Trips - Observed Trips
Non-Work-Related Home-Based Shopping All-Veh

Production District	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
1 Downtown	-494	217	138	-45	1	-211	38	25	32	70	107	85	-35	34	9	4	1	0	0	0	7	4	13	0
2 Kakaako	326	-294	21	157	9	96	69	23	28	29	-196	-350	9	31	4	3	0	0	0	0	9	6	20	0
3 Makiki	446	162	-1249	609	-60	180	201	-456	104	180	-44	138	59	-286	-16	13	0	0	0	0	34	17	-32	0
4 McCully	48	-760	641	-599	52	174	512	160	46	91	-388	145	36	-136	-179	6	1	0	0	1	18	8	123	0
5 Waikiki	421	760	-553	-923	-32	-17	417	-32	34	65	164	-16	24	53	-296	-53	1	2	1	0	14	10	-44	0
6 Diamond Hd	199	-105	351	96	33	-260	-620	161	43	67	31	-312	25	-85	15	2	1	1	1	1	24	11	320	0
7 Kaimuki	-216	-879	299	1183	16	-674	-931	230	56	-6	201	228	48	116	28	20	1	1	0	2	34	21	222	0
8 Manoa	15	-48	-501	537	-32	197	111	-505	32	-10	138	-124	18	56	15	1	0	0	0	0	19	10	71	0
9 Nuuanu	-890	230	107	-37	12	247	202	31	-645	205	40	330	75	101	35	10	1	0	0	0	79	62	-195	0
10 Kalihi	-57	140	-50	192	7	129	124	55	29	-1154	-526	426	166	297	-14	-47	3	0	0	1	210	23	46	0
11 Iwilei	-102	95	96	-79	1	57	38	19	50	154	-341	163	-64	110	21	6	0	0	0	0	29	-269	16	0
12 Airport PH	93	46	67	165	2	46	31	17	17	103	324	-619	289	-664	98	28	3	0	0	0	-64	6	12	0
13 Salt Lake	292	155	75	110	2	-165	93	48	49	153	249	34	-1357	1045	-792	-137	14	0	1	2	74	10	45	0
14 PC Aiea	-189	95	184	-667	5	141	-370	38	-39	-270	-457	522	596	-1822	1816	354	-87	0	0	1	98	15	36	0
15 Waipahu	41	15	30	67	1	23	17	8	10	35	96	720	-127	526	-2270	512	261	2	3	0	21	3	6	0
16 Mililani	-144	20	-59	-209	3	27	-54	15	10	31	-24	-216	71	-349	953	112	83	-355	38	2	19	15	11	0
17 Ewa	-88	27	33	-121	1	21	13	17	3	27	64	-1003	57	1163	105	-39	-357	12	5	8	20	13	19	0
18 Waianae	59	-30	32	-641	1	31	21	24	3	24	52	160	45	-149	612	-770	50	327	10	24	33	31	51	0
19 NorthShore	9	9	12	-10	0	8	6	5	0	8	15	14	8	-380	160	91	10	2	-44	48	9	7	13	0
20 Koolauloa	14	10	8	29	0	7	5	7	2	4	9	69	7	25	-126	30	6	2	-18	-76	-37	9	14	0
21 Kaneohe	76	67	94	92	2	73	43	26	40	83	196	-501	-13	144	-121	-165	5	0	0	2	-292	293	-144	0
22 Kailua	149	41	89	10	-40	86	21	19	53	61	149	-6	26	76	-92	11	4	1	0	2	-145	-284	-231	0
23 E Honolulu	-18	23	132	79	15	-191	28	46	40	56	152	118	30	72	19	14	1	0	0	1	-211	-24	-382	0
Totals	-10	-4	-3	-5	-1	25	15	-19	-3	6	11	5	-7	-22	-16	6	2	-5	-3	19	2	-3	10	0

Estimated Trips / Observed Trips
Non-Work-Related Home-Based Shopping All-Veh

Production District	Attraction District 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
1 Downtown	.7	.0	.0	.9	.0	.2	.0	.0	.0	.0	2.1	.0	.4	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	1.0
2 Kakaako	.0	.6	1.1	1.3	.0	.0	.0	.0	.0	.0	.4	.1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	1.0
3 Makiki	1.7	1.2	.7	1.3	.3	1.9	3.2	.4	.0	.0	.9	2.1	.0	.3	.6	.0	.0	.0	.0	.0	.0	.0	.7	1.0
4 McCully	1.1	.5	3.5	.9	.0	1.4	.0	2.6	.0	.0	.3	.0	.0	.3	.1	.0	.0	.0	.0	.0	.0	.0	.0	1.0
5 Waikiki	3.8	7.0	.6	.9	.9	1.0	4.2	.8	.0	.0	.0	.9	.0	.0	.0	.1	.0	.0	.0	.0	.0	.0	.7	1.0
6 Diamond Hd	.0	.6	.0	1.1	.0	.9	.7	.0	.0	.0	1.2	.3	.0	.5	.0	.0	.0	.0	.0	.0	.0	.0	.0	1.0
7 Kaimuki	.6	.3	2.1	2.6	.0	.8	.6	3.9	.0	1.0	4.3	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	2.3	1.0
8 Manoa	1.1	.6	.4	3.8	.3	2.7	2.0	.6	.0	.8	.0	.4	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	1.0
9 Nuuanu	.5	9.8	1.3	1.0	.0	9.5	.0	1.4	.3	3.4	1.1	.0	.0	2.1	.0	.0	.0	.0	.0	.0	4.4	.0	.2	1.0
10 Kalihi	.9	5.7	.8	1.5	.0	3.8	.0	.0	1.3	.6	.7	2.5	.0	4.1	.8	.3	.0	.0	.0	.0	.0	.0	.0	1.0
11 Iwilei	.9	.0	.0	.7	.0	.0	.0	.0	.0	.0	.7	3.0	.5	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	1.0
12 Airport PH	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.8	4.6	.5	.0	.0	.0	.0	.0	.0	.3	.0	.0	1.0
13 Salt Lake	.0	.0	1.6	1.3	.0	.4	.0	.0	.0	1.9	1.5	1.0	.6	2.6	.3	.4	.0	.0	.0	.0	.0	.0	.0	1.0
14 PC Aiea	.5	.0	.0	.4	.0	.0	.2	.0	.6	.5	.5	1.2	.0	.9	11.7	.0	.5	.0	.0	.0	.0	.0	.0	1.0
15 Waipahu	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	7.1	.4	1.2	.7	3.0	.0	.0	.0	.0	.0	.0	.0	1.0
16 Mililani	.4	.0	.4	.3	.0	.0	.3	.0	.0	.0	.8	.8	.0	.9	1.5	1.0	.0	.0	.0	.0	.0	.0	.0	1.0
17 Ewa	.3	.0	.0	.4	.0	.0	.0	.0	.0	.0	.0	.3	.0	7.1	1.0	.9	.8	.0	.0	.0	.0	.0	.0	1.0
18 Waianae	.0	.6	.0	.2	.0	.0	.0	.0	.0	.0	.0	1.6	.0	.8	.0	.2	1.2	1.1	.0	.0	.0	.0	.0	1.0
19 NorthShore	.0	.0	.0	.8	.0	.0	.0	.0	.0	.0	.0	1.2	.0	.3	.0	1.1	.0	.0	1.0	.0	.0	.0	.0	1.0
20 Koolauloa	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.1	.0	.0	.0	.8	1.0	.4	.0	.0	1.0
21 Kaneohe	2.7	.0	.0	1.7	.0	.0	.0	.0	.0	2.5	4.5	.3	.8	.0	.2	.1	.0	.0	.0	.0	1.0	1.3	.2	1.0
22 Kailua	.0	2.2	.0	1.0	.0	.0	1.6	.0	.0	.0	.0	1.0	.0	.0	.2	.0	.0	.0	.0	.0	.9	1.0	.3	1.0
23 E Honolulu	.9	1.3	2.0	1.1	.0	.9	1.1	1.5	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.2	.8	1.0	1.0
Totals	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0



NWK-HBSHOP, All Veh
Observed Average Trip Length: 6.58 Min
Observed Average Trip Length: 6.62 Min
30.0%
25.0%
20.0%
15.0%
10.0%
5.0%
0.0%
Percent of trips
2
6
10
14
18
22
26
30
34
38
42
46
50
54
58
time (min)
Obs
Est

Estimated Trips
Non-Work-Related Home-Based Other All-Veh

Production District	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
	Attraction District																							
1 Downtown	2031	405	785	606	278	185	149	159	716	220	486	323	197	119	12	15	6	6	2	3	58	81	73	6915
2 Kakaako	930	582	861	801	430	181	148	151	295	77	164	126	76	55	7	7	2	5	0	2	28	42	75	5045
3 Makiki	2706	1354	5739	4214	2043	933	729	3839	1839	458	942	838	538	287	40	37	11	16	3	19	148	207	350	27290
4 McCully	2919	1485	3764	8685	4459	1885	1404	1705	1188	338	617	611	385	233	32	38	14	25	4	17	122	166	628	30724
5 Waikiki	4390	1453	3112	5205	11015	1943	979	1136	844	250	455	440	276	153	26	31	8	57	7	29	84	126	433	32452
6 Diamond Hd	957	457	1449	1998	2538	3623	3051	1183	606	190	304	360	215	165	26	23	7	6	5	7	88	119	977	18354
7 Kaimuki	1323	579	1955	2403	1899	2857	4110	1602	845	264	405	512	297	244	30	39	16	13	4	13	124	176	1212	20922
8 Manoa	2466	470	1785	1814	1019	940	804	3592	733	211	306	395	230	199	33	28	16	10	3	8	101	140	398	15701
9 Nuuanu	3103	1181	2632	1955	1041	923	791	858	4428	1065	1297	1349	778	635	83	73	27	20	4	19	534	929	398	24123
10 Kalihi	2802	713	1782	1490	796	633	543	576	3030	3819	2287	2538	1507	1129	138	116	47	38	5	29	697	400	297	25412
11 Iwilei	1376	363	696	583	293	259	210	218	769	2022	1461	1205	639	435	45	38	18	5	2	7	160	105	105	11014
12 Airport PH	708	215	533	438	255	213	181	185	462	422	748	8285	1871	1976	233	177	69	19	10	15	156	108	107	17386
13 Salt Lake	2103	656	1594	1337	751	573	489	521	1326	1260	1744	8622	10288	4481	615	478	182	84	24	46	408	277	298	38157
14 PC Aiea	1352	445	957	775	476	411	362	357	831	708	861	6409	2925	25640	3217	2067	807	36	66	46	348	249	233	49578
15 Waipahu	620	182	406	398	307	189	159	182	359	299	325	2319	970	8203	15357	3071	2565	304	89	83	150	150	147	36834
16 Mililani	2382	223	467	405	305	241	202	212	407	295	382	2546	1135	4115	4155	59818	1325	99	1410	147	245	234	184	80934
17 Ewa	446	162	332	304	220	170	145	150	294	203	273	2735	822	7577	4556	2265	22495	344	100	96	178	179	127	44173
18 Waianae	120	56	115	152	157	73	64	71	97	51	81	363	179	456	360	295	2698	14638	112	300	140	229	124	20931
19 NorthShore	54	17	40	56	59	25	17	30	40	16	26	127	58	165	105	2298	45	62	10897	525	38	59	40	14799
20 Koolauloa	29	9	25	34	36	15	14	16	23	10	14	34	14	21	7	28	7	53	344	12748	150	61	21	13713
21 Kaneohe	1182	381	806	683	423	386	330	324	1057	799	729	1353	767	721	110	121	52	21	22	309	27568	6664	239	45047
22 Kailua	1822	237	494	466	344	239	198	208	778	207	249	395	204	185	38	86	21	225	16	111	3513	31070	432	41538
23 E Honolulu	1343	588	1843	2095	1576	3452	2387	1453	846	283	418	631	357	331	57	69	31	25	20	46	220	1034	19741	38846
Totals	37164	12213	32172	36897	30720	20349	17466	18728	21813	13467	14574	42516	24728	57525	29282	71218	30469	16111	13149	14625	35258	42805	26639	659888

Observed Trips
Non-Work-Related Home-Based Other All-Veh

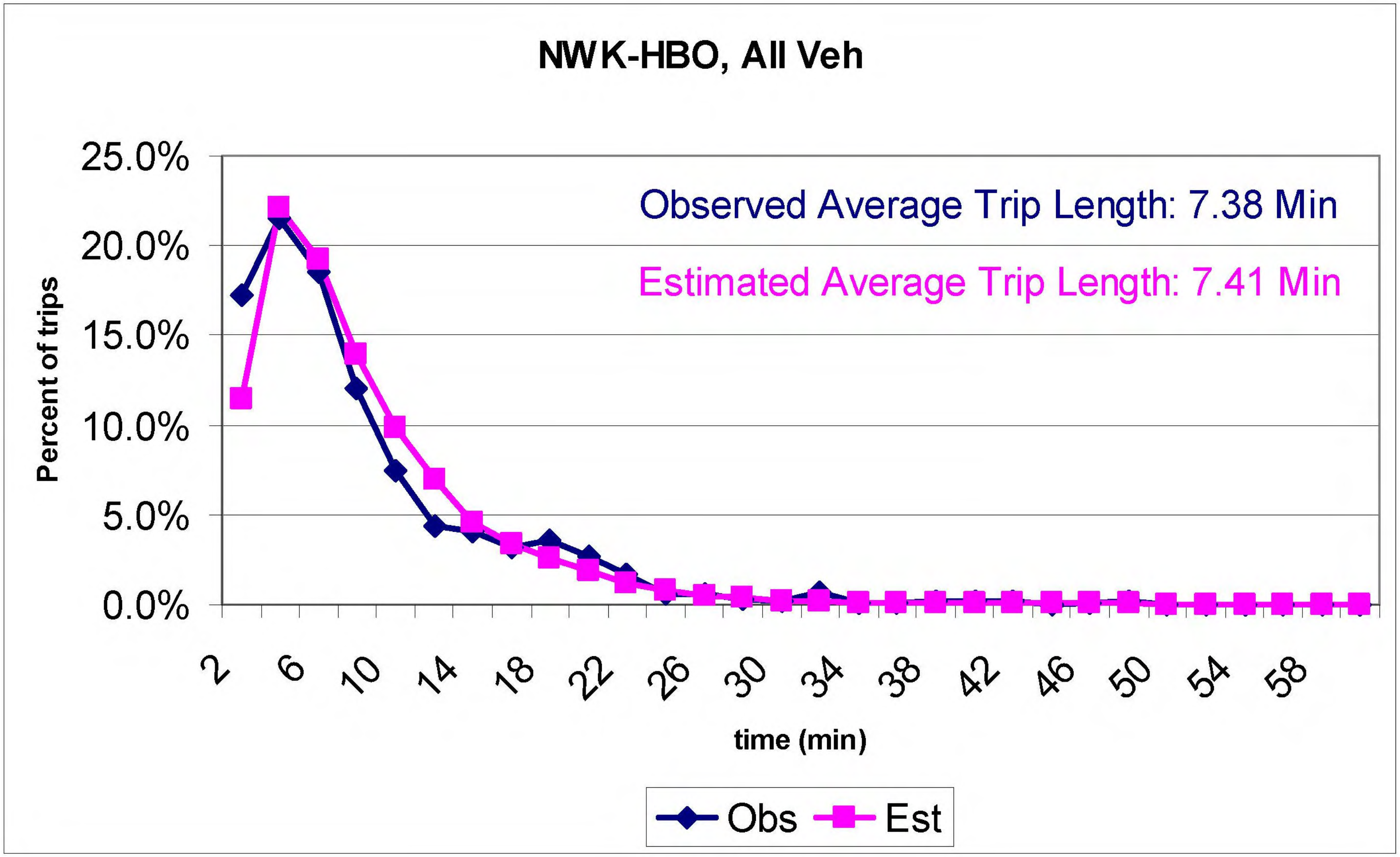
Production District	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
1 Downtown	2454	341	1008	792	269	0	634	16	528	118	332	101	0	0	0	0	116	0	0	0	0	206	0	6915
2 Kakaako	354	744	1650	953	177	0	0	140	471	0	0	0	275	0	281	0	0	0	0	0	0	0	0	5045
3 Makiki	1135	958	9206	3820	1976	116	1121	4252	1450	432	168	176	96	444	133	0	188	0	152	402	177	50	838	27290
4 McCully	3067	1964	3683	11552	3525	1771	934	889	116	120	1077	591	249	227	171	0	0	0	0	0	128	45	615	30724
5 Waikiki	4679	711	2043	5001	11108	1800	197	797	1037	0	726	1304	1143	309	0	0	0	0	62	1038	0	0	497	32452
6 Diamond Hd	1154	836	1289	1310	646	5806	3682	1063	237	217	127	575	0	171	140	0	0	0	211	0	125	78	687	18354
7 Kaimuki	410	832	1772	2152	1284	3410	6275	724	645	0	670	312	55	52	0	65	110	0	0	85	608	645	816	20922
8 Manoa	2405	262	2389	1801	1003	549	286	5507	271	96	0	716	298	0	0	0	0	0	0	0	0	0	118	15701
9 Nuuanu	3121	1952	1576	1823	805	840	458	1108	6198	565	1289	1594	0	337	71	76	158	109	0	0	358	1109	576	24123
10 Kalihi	4241	298	496	921	731	472	69	381	3434	6620	3803	424	144	687	1079	96	0	276	133	0	129	928	50	25412
11 Iwilei	956	0	1320	503	36	119	117	0	1351	2294	2678	4	143	136	0	53	0	0	0	0	641	663	0	11014
12 Airport PH	366	257	320	0	0	168	41	0	318	30	0	12928	621	1659	295	81	119	0	99	0	0	0	84	17386
13 Salt Lake	1832	141	971	752	1893	0	103	416	1269	0	486	7602	15765	3423	487	1947	242	324	0	0	0	434	70	38157
14 PC Aiea	1329	489	696	782	152	581	133	891	483	993	402	5369	2030	31641	1664	622	709	0	166	0	0	320	126	49578
15 Waipahu	593	324	0	200	496	0	100	188	576	176	773	1357	316	7915	18146	2760	901	1373	0	0	0	640	0	36834
16 Mililani	3632	142	767	788	1472	99	0	569	0	125	248	1694	1933	2499	2512	61153	1535	0	861	47	514	344	0	80934
17 Ewa	373	172	535	33	1194	0	0	0	815	113	389	2802	1208	6723	3463	1411	23940	0	158	115	657	0	72	44173
18 Waianae	216	604	0	0	614	0	274	0	0	397	614	764	0	0	510	524	2447	13967	0	0	0	0	0	20931
19 NorthShore	0	0	0	0	0	113	0	0	0	0	0	299	0	156	125	2376	0	0	10942	788	0	0	0	14799
20 Koolauloa	171	0	0	171	0	0	0	0	0	249	0	96	0	132	0	0	0	0	360	11951	413	170	0	13713
21 Kaneohe	1485	430	715	966	785	390	426	329	1461	745	311	1782	237	752	51	0	0	0	0	141	27994	6047	0	45047
22 Kailua	2030	290	470	850	750	138	250	380	198	124	105	295	231	260	0	0	0	104	0	109	3374	30914	666	41538
23 E Honolulu	1192	449	1294	1724	1823	3957	2357	1074	921	56	388	1698	0	0	55	55	0	0	0	0	150	221	21432	38846
Totals	37195	12196	32200	36894	30739	20329	17457	18724	21779	13470	14586	42483	24744	57523	29183	71219	30465	16153	13144	14676	35268	42814	26647	659888

Estimated Trips - Observed Trips
Non-Work-Related Home-Based Other All-Veh

Production District	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
	Attraction District																							
1 Downtown	-423	64	-223	-186	9	185	-485	143	188	102	154	222	197	119	12	15	-110	6	2	3	58	-125	73	0
2 Kakaako	576	-162	-789	-152	253	181	148	11	-176	77	164	126	-199	55	-274	7	2	5	0	2	28	42	75	0
3 Makiki	1571	396	-3467	394	67	817	-392	-413	389	26	774	662	442	-157	-93	37	-177	16	-149	-383	-29	157	-488	0
4 McCully	-148	-479	81	-2867	934	114	470	816	1072	218	-460	20	136	6	-139	38	14	25	4	17	-6	121	13	0
5 Waikiki	-289	742	1069	204	-93	143	782	339	-193	250	-271	-864	-867	-156	26	31	8	57	-55	-1009	84	126	-64	0
6 Diamond Hd	-197	-379	160	688	1892	-2183	-631	120	369	-27	177	-215	215	-6	-114	23	7	6	-206	7	-37	41	290	0
7 Kaimuki	913	-253	183	251	615	-553	-2165	878	200	264	-265	200	242	192	30	-26	-94	13	4	-72	-484	-469	396	0
8 Manoa	61	208	-604	13	16	391	518	-1915	462	115	306	-321	-68	199	33	28	16	10	3	8	101	140	280	0
9 Nuuanu	-18	-771	1056	132	236	83	333	-250	-1770	500	8	-245	778	298	12	-3	-131	-89	4	19	176	-180	-178	0
10 Kalihi	-1439	415	1286	569	65	161	474	195	-404	-2801	-1516	2114	1363	442	-941	20	47	-238	-128	29	568	-528	247	0
11 Iwilei	420	363	-624	80	257	140	93	218	-582	-272	-1217	1201	496	299	45	-15	18	5	2	7	-481	-558	105	0
12 Airport PH	342	-42	213	438	255	45	140	185	144	392	748	-4643	1250	317	-62	96	-50	19	-89	15	156	108	23	0
13 Salt Lake	271	515	623	585	-1142	573	386	105	57	1260	1258	1020	-5477	1058	128	-1469	-60	-240	24	46	408	-157	228	0
14 PC Aiea	23	-44	261	-7	324	-170	229	-534	348	-285	459	1040	895	-6001	1553	1445	98	36	-100	46	348	-71	107	0
15 Waipahu	27	-142	406	198	-189	189	59	-6	-217	123	-448	962	654	288	-2789	311	1664	-1069	89	83	150	-490	147	0
16 Mililani	-1250	81	-300	-383	-1167	142	202	-357	407	170	134	852	-798	1616	1643	-1335	-210	99	549	100	-269	-110	184	0
17 Ewa	73	-10	-203	271	-974	170	145	150	-521	90	-116	-67	-386	854	1093	854	-1445	344	-58	-19	-479	179	55	0
18 Waianae	-96	-548	115	152	-457	73	-210	71	97	-346	-533	-401	179	456	-150	-229	251	671	112	300	140	229	124	0
19 NorthShore	54	17	40	56	59	-88	17	30	40	16	26	-172	58	9	-20	-78	45	62	-45	-263	38	59	40	0
20 Koolauloa	-142	9	25	-137	36	15	14	16	23	-239	14	-62	14	-111	7	28	7	53	-16	797	-263	-109	21	0
21 Kaneohe	-303	-49	91	-283	-362	-4	-96	-5	-404	54	418	-429	530	-31	59	121	52	21	22	168	-426	617	239	0
22 Kailua	-208	-53	24	-384	-406	101	-52	-172	580	83	144	100	-27	-75	38	86	21	121	16	2	139	156	-234	0
23 E Honolulu	151	139	549	371	-247	-505	30	379	-75	227	30	-1067	357	331	2	14	31	25	20	46	70	813	-1691	0
Totals	-31	17	-28	3	-19	20	9	4	34	-3	-12	33	-16	2	99	-1	4	-42	5	-51	-10	-9	-8	0

Estimated Trips / Observed Trips
Non-Work-Related Home-Based Other All-Veh

Production District	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
1 Downtown	.8	1.2	.8	.8	1.0	.0	.2	9.9	1.4	1.9	1.5	3.2	.0	.0	.0	.0	.1	.0	.0	.0	.0	.4	.0	1.0
2 Kakaako	2.6	.8	.5	.8	2.4	.0	.0	1.1	.6	.0	.0	.0	.3	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	1.0
3 Makiki	2.4	1.4	.6	1.1	1.0	8.0	.7	.9	1.3	1.1	5.6	4.8	5.6	.6	.3	.0	.1	.0	.0	.0	.8	4.1	.4	1.0
4 McCully	1.0	.8	1.0	.8	1.3	1.1	1.5	1.9	10.2	2.8	.6	1.0	1.5	1.0	.2	.0	.0	.0	.0	.0	1.0	3.7	1.0	1.0
5 Waikiki	.9	2.0	1.5	1.0	1.0	1.1	5.0	1.4	.8	.0	.6	.3	.2	.5	.0	.0	.0	.0	.1	.0	.0	.0	.9	1.0
6 Diamond Hd	.8	.5	1.1	1.5	3.9	.6	.8	1.1	2.6	.9	2.4	.6	.0	1.0	.2	.0	.0	.0	.0	.0	.7	1.5	1.4	1.0
7 Kaimuki	3.2	.7	1.1	1.1	1.5	.8	.7	2.2	1.3	.0	.6	1.6	5.4	4.7	.0	.6	.1	.0	.0	.2	.2	.3	1.5	1.0
8 Manoa	1.0	1.8	.7	1.0	1.0	1.7	2.8	.7	2.7	2.2	.0	.6	.8	.0	.0	.0	.0	.0	.0	.0	.0	.0	3.4	1.0
9 Nuuanu	1.0	.6	1.7	1.1	1.3	1.1	1.7	.8	.7	1.9	1.0	.8	.0	1.9	1.2	1.0	.2	.2	.0	.0	1.5	.8	.7	1.0
10 Kalihi	.7	2.4	3.6	1.6	1.1	1.3	7.9	1.5	.9	.6	.6	6.0	10.5	1.6	.1	1.2	.0	.1	.0	.0	5.4	.4	5.9	1.0
11 Iwilei	1.4	.0	.5	1.2	8.1	2.2	1.8	.0	.6	.9	.5	301.3	4.5	3.2	.0	.7	.0	.0	.0	.0	.2	.2	.0	1.0
12 Airport PH	1.9	.8	1.7	.0	.0	1.3	4.4	.0	1.5	14.1	.0	.6	3.0	1.2	.8	2.2	.6	.0	.1	.0	.0	.0	1.3	1.0
13 Salt Lake	1.1	4.7	1.6	1.8	.4	.0	4.7	1.3	1.0	.0	3.6	1.1	.7	1.3	1.3	.2	.8	.3	.0	.0	.0	.6	4.3	1.0
14 PC Aiea	1.0	.9	1.4	1.0	3.1	.7	2.7	.4	1.7	.7	2.1	1.2	1.4	.8	1.9	3.3	1.1	.0	.4	.0	.0	.8	1.8	1.0
15 Waipahu	1.0	.6	.0	2.0	.6	.0	1.6	1.0	.6	1.7	.4	1.7	3.1	1.0	.8	1.1	2.8	.2	.0	.0	.0	.2	.0	1.0
16 Mililani	.7	1.6	.6	.5	.2	2.4	.0	.4	.0	2.4	1.5	1.5	.6	1.6	1.7	1.0	.9	.0	1.6	3.1	.5	.7	.0	1.0
17 Ewa	1.2	.9	.6	9.2	.2	.0	.0	.0	.4	1.8	.7	1.0	.7	1.1	1.3	1.6	.9	.0	.6	.8	.3	.0	1.8	1.0
18 Waianae	.6	.1	.0	.0	.3	.0	.2	.0	.0	.1	.1	.5	.0	.0	.7	.6	1.1	1.0	.0	.0	.0	.0	.0	1.0
19 NorthShore	.0	.0	.0	.0	.0	.2	.0	.0	.0	.0	.0	.4	.0	1.1	.8	1.0	.0	.0	1.0	.7	.0	.0	.0	1.0
20 Koolauloa	.2	.0	.0	.2	.0	.0	.0	.0	.0	.0	.0	.4	.0	.2	.0	.0	.0	.0	1.0	1.1	.4	.4	.0	1.0
21 Kaneohe	.8	.9	1.1	.7	.5	1.0	.8	1.0	.7	1.1	2.3	.8	3.2	1.0	2.2	.0	.0	.0	.0	2.2	1.0	1.1	.0	1.0
22 Kailua	.9	.8	1.1	.5	.5	1.7	.8	.5	3.9	1.7	2.4	1.3	.9	.7	.0	.0	.0	2.2	.0	1.0	1.0	1.0	.6	1.0
23 E Honolulu	1.1	1.3	1.4	1.2	.9	.9	1.0	1.4	.9	5.1	1.1	.4	.0	.0	1.0	1.3	.0	.0	.0	.0	1.5	4.7	.9	1.0
Totals	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0



NWK-HBO, All Veh
Observed Average Trip Length: 7.38 Min
Estimated Average Trip Length: 7.41 Min
Percent of trips
25.0%
20.0%
15.0%
10.0%
5.0%
0.0%
2
6
10
14
18
22
26
30
34
38
42
46
50
54
58
time (min)
Obs
Est

Estimated Trips
Non-Work Related Non-Home-Based

Production District	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
1 Downtown	6274	1824	2152	1573	512	628	382	490	1504	664	1559	564	346	419	108	125	66	66	46	42	218	185	246	19993
2 Kakaako	688	1146	1059	2065	412	274	163	213	273	279	229	125	74	105	34	41	23	26	15	18	56	50	105	7473
3 Makiki	1507	1407	4077	4273	947	947	573	1021	2277	419	610	385	229	296	87	101	59	59	42	34	167	131	319	19967
4 McCully	1051	1268	3329	9781	2156	1645	958	1470	707	363	481	365	219	293	94	127	68	75	50	47	170	132	483	25332
5 Waikiki	187	331	560	1066	4979	1055	387	411	134	81	102	109	59	97	41	75	45	45	32	26	73	59	177	10131
6 Diamond Hd	341	275	802	1147	1406	4744	1713	1221	292	164	215	202	118	186	71	124	72	70	51	47	122	108	1004	14495
7 Kaimuki	238	178	577	746	538	1787	2998	876	156	110	147	130	75	111	41	69	39	39	28	25	73	60	510	9551
8 Manoa	594	430	1546	1870	879	1678	1057	6880	386	269	356	310	179	275	102	168	100	97	68	63	179	150	528	18164
9 Nuuanu	1451	553	1097	806	304	329	277	271	1991	801	928	511	305	381	102	121	66	60	48	41	251	216	196	11106
10 Kalihi	369	141	247	218	98	158	97	127	564	1493	1257	520	326	366	89	84	46	43	30	30	218	88	84	6693
11 Iwilei	1401	484	638	530	205	308	186	256	796	1064	4675	1175	575	1124	134	123	68	59	44	37	274	121	152	14429
12 Airport PH	384	191	394	323	166	236	142	194	332	605	1225	10476	1981	2023	1102	379	195	159	116	101	318	1711	202	22955
13 Salt Lake	220	126	238	201	105	140	86	116	196	348	509	1788	2416	1207	251	215	115	103	70	64	205	126	128	8973
14 PC Aiea	235	125	236	212	125	164	102	136	183	309	375	2047	943	20320	3181	1136	531	199	143	119	306	234	207	31568
15 Waipahu	60	43	68	72	56	59	40	51	56	72	101	585	199	4441	11821	1846	1389	139	86	88	153	152	117	21694
16 Mililani	68	56	72	98	98	107	60	92	74	73	91	413	171	1065	2229	22574	388	256	343	165	306	299	247	29345
17 Ewa	36	30	37	51	50	57	38	47	36	37	46	189	76	581	1564	351	5680	166	94	83	167	158	131	9705
18 Waianae	27	23	30	42	38	44	26	32	27	26	34	107	50	147	102	181	124	4909	74	69	131	123	106	6472
19 NorthShore	32	25	44	45	51	49	35	42	28	31	40	129	62	171	112	407	127	128	3581	96	154	150	122	5661
20 Koolauloa	22	22	31	36	38	41	24	34	26	23	31	101	49	134	88	171	99	100	134	3109	124	116	97	4650
21 Kaneohe	88	63	103	99	71	93	52	72	116	172	161	248	131	257	136	245	143	143	103	95	15051	1415	145	19202
22 Kailua	134	77	110	116	88	105	64	84	165	87	105	215	98	252	163	311	182	184	127	119	2017	13911	229	18943
23 E Honolulu	117	97	239	310	202	895	408	331	113	70	90	148	78	167	94	187	110	106	76	71	141	172	7590	11812
Totals	15524	8915	17686	25680	13524	15543	9868	14467	10432	7560	13367	20842	8759	34418	21746	29161	9735	7231	5401	4589	20874	19867	13125	348314

Observed Trips
Non-Work Related Non-Home Based

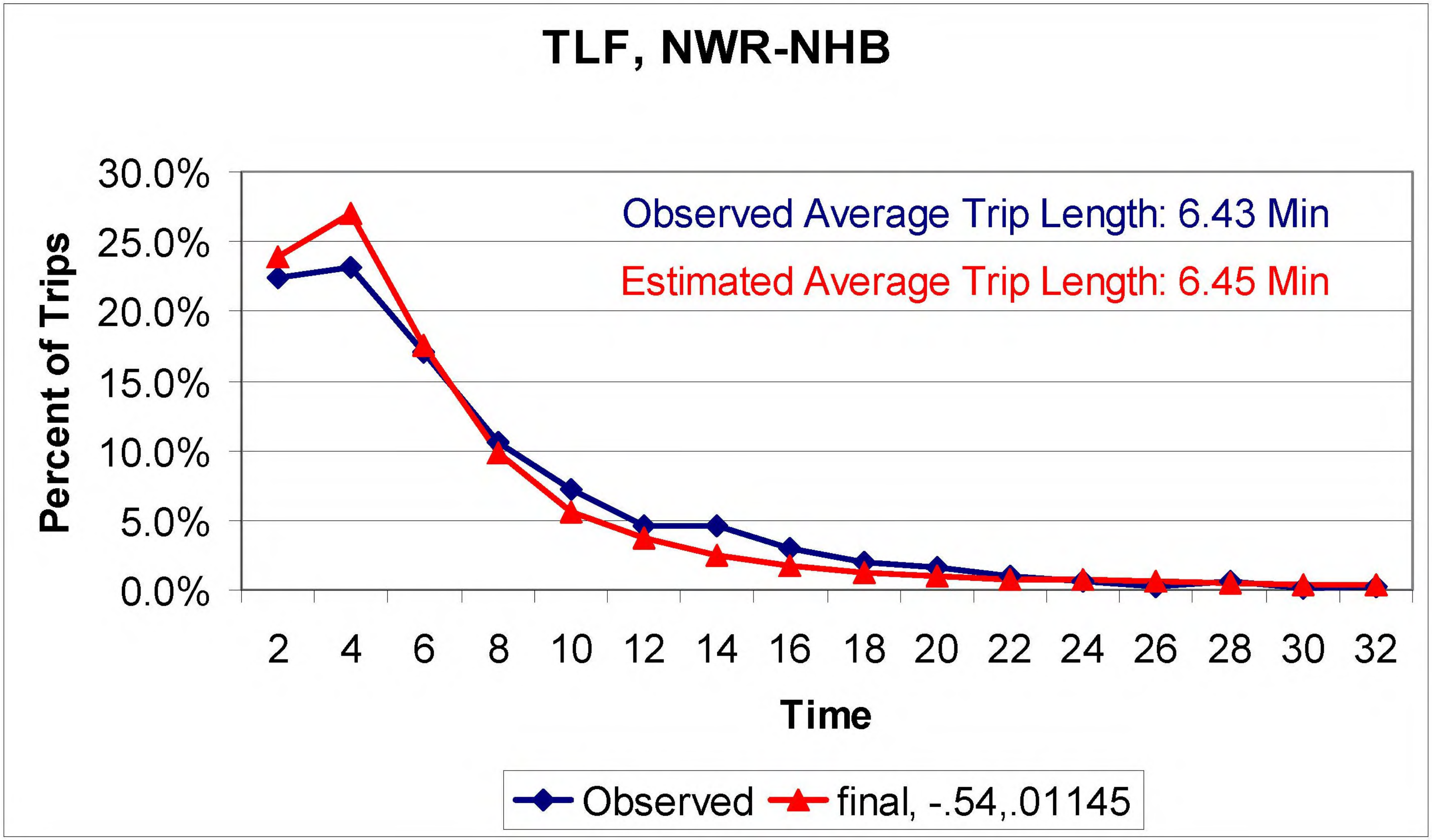
Production District	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
1 Downtown	5670	829	2833	1706	663	882	107	598	784	125	2686	1186	234	316	97	99	0	143	212	0	271	134	418	19993
2 Kakaako	1170	1068	1021	1736	390	198	75	122	97	0	379	468	0	287	0	50	0	0	0	0	67	46	299	7473
3 Makiki	1624	623	4645	3439	691	1281	228	1588	1347	157	654	1207	93	503	940	0	0	0	41	0	246	241	419	19967
4 McCully	830	1678	3748	8543	1907	1991	1309	723	864	494	934	437	0	249	143	417	0	0	0	0	98	264	703	25332
5 Waikiki	317	522	523	1018	4123	1457	468	520	297	0	0	37	0	264	94	0	0	37	0	0	178	47	229	10131
6 Diamond Hd	562	891	1003	1387	1492	3818	2368	415	536	39	68	383	117	0	0	0	0	0	0	43	0	109	1264	14495
7 Kaimuki	363	255	190	587	277	2583	2546	1032	250	109	0	464	0	0	55	0	0	0	0	0	98	98	644	9551
8 Manoa	841	237	1008	1890	610	829	1444	7345	828	139	458	507	180	978	0	80	0	0	0	0	396	218	176	18164
9 Nuuanu	1134	931	357	1485	41	651	318	154	2810	352	822	238	132	179	388	64	76	0	166	0	346	331	131	11106
10 Kalihi	284	256	61	328	0	176	42	0	630	2018	636	195	28	877	98	117	143	0	0	86	622	96	0	6693
11 Iwilei	990	343	744	461	974	304	0	438	615	2397	4335	381	204	1101	416	199	82	0	0	0	177	138	130	14429
12 Airport PH	205	88	515	1287	140	0	112	456	148	247	592	9113	2486	2097	1926	304	313	71	0	0	787	1360	708	22955
13 Salt Lake	257	64	120	350	57	152	0	361	120	70	325	1970	2908	1107	0	507	6	0	181	0	201	100	117	8973
14 PC Aiea	330	339	142	0	157	0	0	362	334	658	421	1863	832	19008	3486	1822	720	101	232	0	0	334	427	31568
15 Waipahu	0	119	225	30	490	0	82	86	94	63	82	278	0	3946	12161	1683	1901	203	234	0	0	17	0	21694
16 Mililani	223	238	99	151	651	36	41	93	0	114	123	508	378	1473	8382	22880	132	668	643	0	0	0	56	29345
17 Ewa	0	0	0	23	0	0	115	0	109	0	0	859	855	1047	427	10	6260	0	0	0	0	0	0	9705
18 Waianae	0	37	0	50	0	0	0	0	0	0	0	0	0	179	194	0	0	6012	0	0	0	0	0	6472
19 NorthShore	0	0	0	0	0	0	0	0	0	133	0	479	0	439	168	569	0	0	3684	189	0	0	0	5661
20 Koolauloa	0	0	0	0	0	0	124	0	0	0	0	0	0	77	0	26	115	0	0	3961	212	94	41	4650
21 Kaneohe	113	85	185	357	0	0	28	67	67	289	302	48	142	160	0	0	0	0	0	215	14470	2510	164	19202
22 Kailua	139	0	36	466	238	204	133	65	246	79	75	98	75	146	334	379	0	0	0	97	2553	13221	359	18943
23 E Honolulu	460	299	263	323	604	983	312	19	259	56	468	115	114	0	0	0	0	0	0	0	173	525	6839	11812
Totals	15512	8902	17718	25617	13505	15545	9852	14444	10435	7539	13360	20834	8778	34433	21765	29206	9748	7235	5393	4591	20895	19883	13124	348314

Estimated Trips - Observed Trips
Non-Work Related Non-Home-Based

Production District	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
1 Downtown	604	995	-681	-133	-151	-254	275	-108	720	539	-1127	-622	112	103	11	26	66	-77	-166	42	-53	51	-172	0
2 Kakaako	-482	78	38	329	22	76	88	91	176	279	-150	-343	74	-182	34	-9	23	26	15	18	-11	4	-194	0
3 Makiki	-117	784	-568	834	256	-334	345	-567	930	262	-44	-822	136	-207	-853	101	59	59	1	34	-79	-110	-100	0
4 McCully	221	-410	-419	1238	249	-346	-351	747	-157	-131	-453	-72	219	44	-49	-290	68	75	50	47	72	-132	-220	0
5 Waikiki	-130	-191	37	48	856	-402	-81	-109	-163	81	102	72	59	-167	-53	75	45	8	32	26	-105	12	-52	0
6 Diamond Hd	-221	-616	-201	-240	-86	926	-655	806	-244	125	147	-181	1	186	71	124	72	70	51	4	122	-1	-260	0
7 Kaimuki	-125	-77	387	159	261	-796	452	-156	-94	1	147	-334	75	111	-14	69	39	39	28	25	-25	-38	-134	0
8 Manoa	-247	193	538	-20	269	849	-387	-465	-442	130	-102	-197	-1	-703	102	88	100	97	68	63	-217	-68	352	0
9 Nuuanu	317	-378	740	-679	263	-322	-41	117	-819	449	106	273	173	202	-286	57	-10	60	-118	41	-95	-115	65	0
10 Kalihi	85	-115	186	-110	98	-18	55	127	-66	-525	621	325	298	-511	-9	-33	-97	43	30	-56	-404	-8	84	0
11 Iwilei	411	141	-106	69	-769	4	186	-182	181	-1333	340	794	371	23	-282	-76	-14	59	44	37	97	-17	22	0
12 Airport PH	179	103	-121	-964	26	236	30	-262	184	358	633	1363	-505	-74	-824	75	-118	88	116	101	-469	351	-506	0
13 Salt Lake	-37	62	118	-149	48	-12	86	-245	76	278	184	-182	-492	100	251	-292	109	103	-111	64	4	26	11	0
14 PC Aiea	-95	-214	94	212	-32	164	102	-226	-151	-349	-46	184	111	1312	-305	-686	-189	98	-89	119	306	-100	-220	0
15 Waipahu	60	-76	-157	42	-434	59	-42	-35	-38	9	19	307	199	495	-340	163	-512	-64	-148	88	153	135	117	0
16 Mililani	-155	-182	-27	-53	-553	71	19	-1	74	-41	-32	-95	-207	-408	1391	-306	256	-412	-300	165	306	299	191	0
17 Ewa	36	30	37	28	50	57	-77	47	-73	37	46	-670	-779	-466	1137	341	-580	166	94	83	167	158	131	0
18 Waianae	27	-14	30	-8	38	44	26	32	27	26	34	107	50	-32	-92	181	124	-1103	74	69	131	123	106	0
19 NorthShore	32	25	44	45	51	49	35	42	28	-102	40	-350	62	-268	-56	-162	127	128	-103	-93	154	150	122	0
20 Koolauloa	22	22	31	36	38	41	-100	34	26	23	31	101	49	57	88	145	-16	100	134	-852	-88	22	56	0
21 Kaneohe	-25	-22	-82	-258	71	93	24	5	49	-117	-141	200	-11	97	136	245	143	143	103	-120	581	-1095	-19	0
22 Kailua	-5	77	74	-350	-150	-99	-69	19	-81	8	30	117	23	106	-171	-68	182	184	127	22	-536	690	-130	0
23 E Honolulu	-343	-202	-24	-13	-402	-88	96	312	-146	14	-378	33	-36	167	94	187	110	106	76	71	-32	-353	751	0
Totals	12	13	-32	63	19	-2	16	23	-3	21	7	8	-19	-15	-19	-45	-13	-4	8	-2	-21	-16	1	0

Estimated Trips / Observed Trips
Non-Work Related Non-Home-Based

Production District	Attraction District 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
1 Downtown	1.1	2.2	.8	.9	.8	.7	3.6	.8	1.9	5.3	.6	.5	1.5	1.3	1.1	1.3	.0	.5	.2	.0	.8	1.4	.6	1.0
2 Kakaako	.6	1.1	1.0	1.2	1.1	1.4	2.2	1.7	2.8	.0	.6	.3	.0	.4	.0	.8	.0	.0	.0	.0	.8	1.1	.4	1.0
3 Makiki	.9	2.3	.9	1.2	1.4	.7	2.5	.6	1.7	2.7	.9	.3	2.5	.6	.1	.0	.0	.0	1.0	.0	.7	.5	.8	1.0
4 McCully	1.3	.8	.9	1.1	1.1	.8	.7	2.0	.8	.7	.5	.8	.0	1.2	.7	.3	.0	.0	.0	.0	1.7	.5	.7	1.0
5 Waikiki	.6	.6	1.1	1.0	1.2	.7	.8	.8	.5	.0	.0	2.9	.0	.4	.4	.0	.0	1.2	.0	.0	.4	1.3	.8	1.0
6 Diamond Hd	.6	.3	.8	.8	.9	1.2	.7	2.9	.5	4.2	3.2	.5	1.0	.0	.0	.0	.0	.0	.0	1.1	.0	1.0	.8	1.0
7 Kaimuki	.7	.7	3.0	1.3	1.9	.7	1.2	.8	.6	1.0	.0	.3	.0	.0	.7	.0	.0	.0	.0	.0	.7	.6	.8	1.0
8 Manoa	.7	1.8	1.5	1.0	1.4	2.0	.7	.9	.5	1.9	.8	.6	1.0	.3	.0	2.1	.0	.0	.0	.0	.5	.7	3.0	1.0
9 Nuuanu	1.3	.6	3.1	.5	7.4	.5	.9	1.8	.7	2.3	1.1	2.1	2.3	2.1	.3	1.9	.9	.0	.3	.0	.7	.7	1.5	1.0
10 Kalihi	1.3	.6	4.0	.7	.0	.9	2.3	.0	.9	.7	2.0	2.7	11.6	.4	.9	.7	.3	.0	.0	.3	.4	.9	.0	1.0
11 Iwilei	1.4	1.4	.9	1.1	.2	1.0	.0	.6	1.3	.4	1.1	3.1	2.8	1.0	.3	.6	.8	.0	.0	.0	1.5	.9	1.2	1.0
12 Airport PH	1.9	2.2	.8	.3	1.2	.0	1.3	.4	2.2	2.4	2.1	1.1	.8	1.0	.6	1.2	.6	2.2	.0	.0	.4	1.3	.3	1.0
13 Salt Lake	.9	2.0	2.0	.6	1.8	.9	.0	.3	1.6	5.0	1.6	.9	.8	1.1	.0	.4	19.2	.0	.4	.0	1.0	1.3	1.1	1.0
14 PC Aiea	.7	.4	1.7	.0	.8	.0	.0	.4	.5	.5	.9	1.1	1.1	1.1	.9	.6	.7	2.0	.6	.0	.0	.7	.5	1.0
15 Waipahu	.0	.4	.3	2.4	.1	.0	.5	.6	.6	1.1	1.2	2.1	.0	1.1	1.0	1.1	.7	.7	.4	.0	.0	8.9	.0	1.0
16 Mililani	.3	.2	.7	.6	.2	3.0	1.5	1.0	.0	.6	.7	.8	.5	.7	2.7	1.0	2.9	.4	.5	.0	.0	.0	4.4	1.0
17 Ewa	.0	.0	.0	2.2	.0	.0	.3	.0	.3	.0	.0	.2	.1	.6	3.7	35.1	.9	.0	.0	.0	.0	.0	.0	1.0
18 Waianae	.0	.6	.0	.8	.0	.0	.0	.0	.0	.0	.0	.0	.0	.8	.5	.0	.0	.8	.0	.0	.0	.0	.0	1.0
19 NorthShore	.0	.0	.0	.0	.0	.0	.0	.0	.0	.2	.0	.3	.0	.4	.7	.7	.0	.0	1.0	.5	.0	.0	.0	1.0
20 Koolauloa	.0	.0	.0	.0	.0	.0	.2	.0	.0	.0	.0	.0	.0	1.7	.0	6.6	.9	.0	.0	.8	.6	1.2	2.4	1.0
21 Kaneohe	.8	.7	.6	.3	.0	.0	1.9	1.1	1.7	.6	.5	5.2	.9	1.6	.0	.0	.0	.0	.0	.4	1.0	.6	.9	1.0
22 Kailua	1.0	.0	3.1	.2	.4	.5	.5	1.3	.7	1.1	1.4	2.2	1.3	1.7	.5	.8	.0	.0	.0	1.2	.8	1.1	.6	1.0
23 E Honolulu	.3	.3	.9	1.0	.3	.9	1.3	17.4	.4	1.3	.2	1.3	.7	.0	.0	.0	.0	.0	.0	.0	.8	.3	1.1	1.0
Totals	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0


TLF, NWR-NHB
Observed Average Trip Length: 6.43 Min
Estimated Average Trip Length: 6.45 Min
Percent of Trips
30.0%
25.0%
20.0%
15.0%
10.0%
5.0%
0.0%
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
Time
Observed
final, -.54,.01145

AR00076999

5. Mode Choice

The Mode Choice model estimates the share of zone-to-zone trips that will use each of the competing methods of travel, based on the relative attractiveness of the competing methods and on the characteristics of both the travelers and the trips that they make. In addition to automobile, transit, and non-motorized modes of travel, the Mode Choice model also considers ridesharing with different occupancy levels; walk- and drive-access to transit; guideway, premium, and local transit paths; walking, and bicycling. The model integrates consideration of these choices in an internally consistent way that describes the trade-offs that travelers make among all of the competing options. The model has been developed by 1) borrowing the mode choice structure and some nesting coefficients from similar models developed in other urban areas, 2) estimating the generic coefficients for time and cost and some nesting coefficients using the 1995 Household Interview Survey data, and 3) calibrating the constants and other alternative-specific parameters in the models against observed travel patterns on Oahu.

5.1. Description

Table 5.1-1 summarizes the key features of the Mode Choice model. The model uses a functional form known as nested logit. Figure 5.1-1 presents the structure of the nested logit model. The model considers ten elemental alternatives:

1-Occ	1-occupant auto (SOV)
2-Occ	2-occupant auto (HOV)
3+-Occ	3-or-more-occupant auto (HOV)
Local	Walking to a local bus-only transit path (Walk to Transit)
Premium	Walking to a local or premium bus-only transit path (Walk to Transit)
Guideway	Walking to a mixed-mode transit path (Walk to Transit)
Park-n-Ride	Driving to a park-n-ride lot and taking transit to work (Drive to Transit)
Kiss-n-Ride	Getting a ride to a transit stop and taking transit to work (Drive to Transit)
Walk	Walking to destination (Auxiliary)
Bicycle	Biking to destination (Auxiliary)

For each zone-to-zone interchange, each of these elemental alternatives is represented by a separate zone-to-zone path developed from the highway network (for 1-Occ, 2-Occ, 3+-Occ, Walk, and Bike) or the transit network (for the five transit alternatives). Currently there is no guideway transit on the island of Oahu; however, this alternative has been included within the model structure to allow for its consideration in the analysis of future alternatives.

The ten elemental alternatives are found at the lowest levels of the structure in Figure 5.1-1. The nested structure is used to reflect the similarities among subgroups of these elemental alternatives. For example, the structure recognizes that the drive-alone and ridesharing options are more closely related to each other than they are to any of the transit options. Consequently, these two options are grouped together in a "nest." The combined utility of these two options then represents the overall attractiveness of "auto" as a modal choice.

Table 5.1-1

Key Features of the Mode Choice Model

Inputs

- Zone-to-zone trip tables from the trip distribution models
- Zone-to-zone time and cost tables from the highway network
- Zone-to-zone time and cost tables from the transit network
- Zone-specific attributes including auto "terminal" times, parking costs, and densities

Outputs

- Zone-to-zone trip tables by purpose and "mode"
- Zone-to-zone composite-impedance tables by purpose

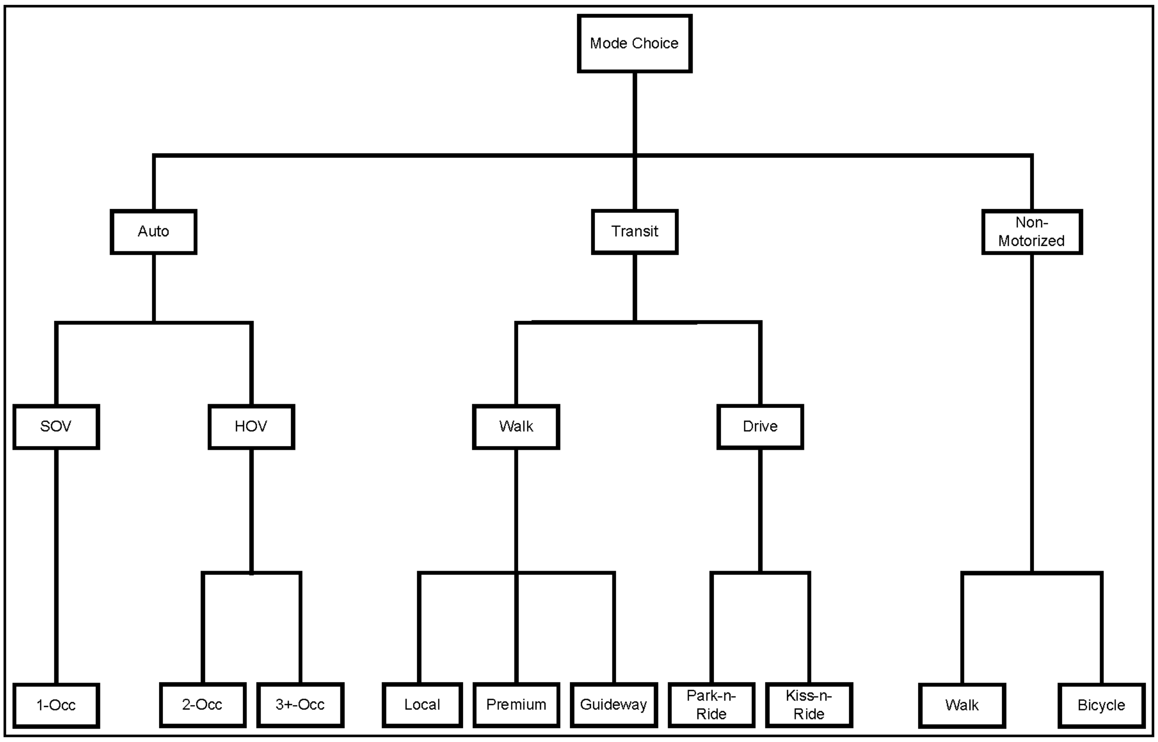
Method

- Nested logit model
- Composite measure of impedance passed upward from each "nest"
- Assumption that all journey-to-work and school (K-12 and college) travel faces peak-period travel conditions and that all other travel faces off-peak conditions

Purposes Facing Peak-Period Conditions	Purposes Facing Off-Peak Conditions
Journey-to-Work – Home-Based Work	Journey-at-Work – Work-Based
Journey-to-Work – Home-Based Non-Work	Journey-at-Work – Non-Work-Based
Journey-to-Work – Work-Based Non-Work	Non-Work-Related – Home-Based Shopping
Journey-to-Work – Non-Home-Based, Non-Work-Based	Non-Work-Related – Home-Based Other
Non-Work-Related – Home-Based College	Non-Work-Related – Non-Home-Based
Non-Work-Related – Home-Based K-12 School	

Analogously on the transit side of the structure, the walk-to-local, walk-to-premium, and walk-to-guideway choices are grouped separately from the Park-n-Ride and Kiss-n-Ride options. Walk-access and drive-access together represent the overall attractiveness of transit in competition with the auto and non-motorized travel modes.

Figure 5.1-1: Structure of the Nested Logit Mode Choice Model



The important property of the nested structure is that it recognizes the differential competition among the elemental alternatives. Switching among alternatives occurs more readily when the alternatives are found in the same nest. Consequently, a traveler who currently uses the Park-n-Ride alternative is more easily switched to the Kiss-n-Ride alternative than to either of the walk-to-transit alternatives. Similarly, a traveler currently driving alone is more easily switched to ride-sharing than to any of the transit options. These “differential elasticities” have been demonstrated in careful calibration of nested mode choice models in several other urban areas in the United States and are a key feature in the realistic analysis of trade-offs among travel modes.

The general structure of this model is the same for all trips regardless of the trip-making purpose.

5.1.1 Computations

The basic logit formulation computes the share of travel that will be captured by each available alternative within each nest. The share is estimated as a function of the attractiveness of each alternative relative to the attractiveness of all other alternatives:

(1) $$S_{t|ijs} = \frac{\exp(U_{t|ijs} / \theta_T)}{\sum_{t' \in T} \exp(U_{t'|ijs} / \theta_T)}$$

$S_{t\|ijs}$	is the share captured by mode t in nest T for travel from zone i to zone j for travelers in socio-economic class s;
$U_{t\|ijs}$	is the utility or attractiveness of mode t for travel from zone i to zone j for travelers in socio-economic class s; and
Σ	is the summation of the utilities across all of the modes in nest T that are available between i and j.
θ_T	is the logsum or nesting coefficient

This calculation is done for each alternative in a nest. To represent the overall attractiveness of the alternatives in each nest, the model computes a composite measure of their utilities:

(2) $$LogSum_T = \ln \sum_{t' \in T} \exp(U_{t'|ijs} / \theta_T)$$

where ln is the natural logarithm operator. This measure is the natural logarithm of the denominator of Equation 1 and is used because it captures the utilities of all of the available modes in an internally consistent way. When the utility of any of the modes in a nest increases, the overall attractiveness of the nest increases. Analogously, when the utility of any mode decreases, the overall attractiveness of the nest decreases. Further, changes in more than one of the modes lead to consistent estimates of the overall impact on the attractiveness of the nest. The LogSum measure is then used to represent the attractiveness of the nested modes in the next higher level of the nested structure, as shown in Equation 3.

(3) $$U_T = \theta_T * LogSum_T$$

For example, Equation 1 is used to compute the share of auto travel captured by the 2-Occ and 3+-Occ alternatives. Equation 2 is then used to compute a LogSum measure of the overall attractiveness of HOV auto travel given the characteristics of the two occupancy alternatives. This measure is then used in another application of Equation 1, with the utility U of the nest given by Equation 3, to compute the share of HOV auto travel in competition with SOV auto travel. Analogous calculations are done on the transit side of the structure to estimates shares within each nest, composite measures of attractiveness, and (ultimately) the overall attractiveness and share for transit in competition with the auto and non-motorized alternatives.

5.1.2 Variables and Coefficients Used to Estimate Utilities

For the elemental alternatives, utility is estimated as a weighted sum of the characteristics of the travel modes, the traveler, and the trip. For example, a simple calculation of utility might be:

(4) $$U_{t|ijs} = a * time_{tij} + b * cost_{tij} + k_{ts}$$

where $U_{t|ijs}$ is the attractiveness of mode t for travel from zone i to zone j for travelers in socio-economic class s;

$time_{tij}$ is the travel time from zone i to zone j using mode t;

$cost_{tij}$ is the travel cost from zone i to zone j using mode t;

a, b are the weights, or coefficients, applied to the times and costs; and

k_{ts} is a constant that represents the net effect of the unincluded attributes of mode t for travelers in socio-economic class s.

The characteristics and weights used in the mode choice models include:

in-vehicle time: travel time in autos, buses, and rail vehicles;

terminal time: time spent walking to/from the automobile parking place and the actual origin/destination of the trip;

operating cost: the cost-per-mile of operating an automobile times the distance of the trip, divided by the number of occupants in the auto*;

parking cost: the average cost of parking an automobile at the destination divided by the number of occupants in the auto*;

walk time: time spent walking to, from, and between transit vehicles;

wait time: total time spent waiting at a transit stop for each bus or rail vehicle used on a trip;

transfers: number of transfers made during a transit trip;

fare: one-way transit fare;

LogSum: composite measures of attractiveness computed for nests using Equation 2; and

* For off-peak purposes (i.e. Non-Work Related – HB Shop, – HB Other, – Non-Home Based, and Journeys-At-Work), the cost is not divided by the auto occupancy.

constants: alternative-specific constants stratified by vehicle ownership class and trip destination to represent the net effect of all other attributes of the modes (safety, reliability, comfort, and so forth) that are not measurable and are therefore not included within the model.

The borrowed components of the models are the structure itself and the values of some coefficients on LogSum variables. The coefficients on time and cost, as well as the non-motorized LogSum coefficient, have been estimated from the Household Interview Survey data collected for this project. The calibrated components include the values of the alternative-specific constants. Note that in this document the coefficients are typically abbreviated with c and constants with k to reduce confusion.

While each trip purpose shares the structure depicted in Figure 5.1-1, each has distinct values of both coefficients and constants.

5.2 Development

The model development effort attempted to estimate both generic and nesting coefficients for each trip purpose for the structure depicted in Figure 5.1-1, using the 1995 Household Interview Survey data. As described above, the mode-choice models consider a large set of trip purposes and paths independently. This requires a substantial number of observations to ensure sufficient sample size for precise coefficient estimates. In many cases, the available number of observations proved insufficient for estimation of some coefficients. Table 5.2-1 displays the distribution of HIS trip observations by purpose and mode chosen.

Table 5.2-1: Distribution of Observations by Purpose and Mode

Purpose	Travel Mode									Grand Total
	1 SOV	2 HOV2	3 HOV3+	4 Walk to Premium	5 Walk to Local	6 PNR	7 KNR	8 Walk	9 Bike	
1: JTW-HBW	3,835	878	188	50	387	14	17	167	75	5,611
2: JTW-HBNW	781	611	340	1	43		1	27	7	1,811
3: JTW-NB	297	293	115		11			21		737
4: JTW-WB	1,255	328	88	3	35	6	2	70	3	1,790
5: NWR-HBK12	61	466	630	4	195	1	9	200	38	1,604
6: NWR-HBCol	259	63	14	5	62		1	24	17	445
7: NWR-HBShp	769	737	497	4	95	1	1	83	10	2,197
8: NWR-HBOth	2,204	2,334	1,812	1	239	2	4	275	44	6,915
9: NWR-NHB	912	1,376	1,112		99		5	159	5	3,668
10: JAW-WB	952	281	107	1	18		1	247	19	1,626
11: JAW-NB	44	40	8					24		116
Grand Total	11,369	7,407	4,911	69	1,184	24	41	1,297	218	26,520

Note: NWR = Non-Work Related, JTW = Journey-To-Work, JAW = Journey-At-Work, HB = Home-Based, WB = Work-Based, NB = Non-Based, and NW = Non-Work

The table illustrates that there are too few observations to warrant estimation of any transit nests. Additionally, attempts to estimate auto occupancy shares yielded counter-intuitive nesting coefficients (i.e. theta values much greater than 1), presumably due high collinearity among the attributes of driving paths (SOV, HOV2, HOV3+). Consequently, the nesting coefficients for the auto and transit paths were borrowed from similar nested logit models in other urban areas.

The data limitations described above focused the mode choice estimation effort on time and cost parameters, along with the nesting coefficient for non-motorized modes. For several reasons, the eleven trip purposes were combined into three for estimation: Journey-to-Work plus Non-Work-Related – Home-Based College (JTW/C); Non-Work Related – Home-Based K-12 School; and others. First, the combinations are behaviorally intuitive. Travelers making journeys to work should share the same value of time whether they stop on the way to work or not. Second, this reduction enhances the precision of resulting estimates. Third, it makes the process more manageable. Table 5.2-2 displays the aggregation of trip purposes into estimation classes.

Table 5.2-2: Distribution of Trips by Purpose and Combined Modeling Purpose

Trip Purpose	Combined Modeling Purposes		
	1 JTW/C	2 Other	3 NWR-HBK12
1: JTW-HBW	5,611		
2: JTW-HBNW	1,811		
3: JTW-NB	737		
4: JTW-WB	1,790		
5: NWR-HBK12			1,604
6: NWR-HBCol	445		
7: NWR-HBShp		2,197	
8: NWR-HBOth		6,915	
9: NWR-NHB		3,668	
10: JAW-WB		1,626	
11: JAW-NB		116	
Grand Total	10,394	14,522	1,604

Appendices A through C contain the nested logit estimation results from various model formulations for the JTW/C, Other, and NWR-HBK12 estimation classes, respectively. Model estimation frequently revealed the relationship between in-vehicle time and out-of-vehicle time to be counterintuitive. Specifically, the coefficient on in-vehicle time was usually positive, which is illogical. To fix this, the relationship between travelers' perception of in-vehicle time (IVT) and walk time was established as one to two (i.e., one minute of walk time is twice as onerous as one minute of IVT), based on modeling experience in other urban areas. For the combined JTW/C, the final model formulations involved two time coefficients:

Time1 = IVT + 2*WalkTime, and

Time2 = WaitTime + 6*Transfers.

The factor of 6 on the number of transfers represents the additional transfer penalty time. This penalty was calibrated using the 1991 DTS Transit Ridership Survey[1] and the current transit network.

For the Other estimation class, a single time coefficient was estimated using the following time computation of perceived travel time:

TIME = IVT + 2*OVT, where

OVT = WalkTime + WaitTime + 6*Transfers.

Table 5.2-3 presents the final coefficient values on time and cost, as well as the non-motorized nesting coefficient, that were estimated using the HIS data. The remaining nesting coefficients, also shown in Table 5.2-3, represent an amalgam of nationwide experience in the estimation of nested models. The system coefficients in Table 5.2-3 are shown at the multinomial level for all trip purposes.

[1] "Task 3.1 On-Board Bus Survey Final Report." Prepared for the Department of Transportation Services, Office of Rapid Transit, City and County of Honolulu. Prepared by Barton-Aschman Associates, Inc. March 1992.

Table 5.2-4a presents the final coefficient values for the JTW/C trip purposes for both the multinomial and nested logit model forms, while Table 5.2-4b displays the final utility equations for the JTW/C trip purposes. Similarly, Tables 5.2-5 and 5.2-6 present the coefficient values and utility equations for the Other and JTW-HBK12 trip purposes, respectively.

Table 5.2-3: Coefficient Values for the Mode Choice Models

Purpose >	Journey To/From Work (JTW)				Journey At Work (JAW)		Non-Work Related (NWR)				
Coefficient v	HBW	HBNW	WB	NB	WB	NB	HBK12	HBCol	HBShp	HBOth	NHB
Generic											
In-vehicle Time	-0.0185	-0.0185	-0.0185	-0.0185	-0.0181	-0.0181	-0.0110	-0.0185	-0.0181	-0.0181	-0.0181
Walk time	-0.0370	-0.0370	-0.0370	-0.0370	-0.0362	-0.0362	-0.0220	-0.0370	-0.0362	-0.0362	-0.0362
Wait time	-0.0318	-0.0318	-0.0318	-0.0318	-0.0362	-0.0362	-0.0185	-0.0318	-0.0362	-0.0362	-0.0362
Cost	-0.0031	-0.0031	-0.0031	-0.0031	-0.0449	-0.0449	-0.0040	-0.0031	-0.0449	-0.0449	-0.0449
Transfers	-0.0918	-0.0918	-0.0918	-0.0918	-0.2172	-0.2172	-0.1110	-0.0918	-0.2172	-0.2172	-0.2172
Nesting Coefficient											
Access	0.447	0.447	0.447	0.447	0.447	0.447	0.447	0.447	0.447	0.447	0.447
Path	0.447	0.447	0.447	0.447	0.447	0.447	0.447	0.447	0.447	0.447	0.447
Lot	0.900	0.900	0.900	0.900	0.900	0.900	0.900	0.900	0.900	0.900	0.900
Auto	0.850	0.850	0.850	0.850	0.850	0.850	0.850	0.850	0.850	0.850	0.850
Occupancy	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750
Auxiliary	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

The mode-specific constants are the result of a calibration process that uses shares from the 1995 HIS and (for transit alternatives) from the 1991 DTS Transit Ridership Survey[2]. Calibration of these constants is an iterative process that estimates the values of the constants necessary to match observed mode shares on Oahu. The models produced by this combination of borrowing and calibration combine the wealth of experience that has been accumulated across the United States together with the Oahu-specific travel information in the two surveys to produce models that realistically represent current travel patterns on the island.

The new Mode Choice application program has an auto-calibration capability, so that it can perform automatically the iterative calibration of constants based on user-provided observed shares for each travel mode, socioeconomic stratum, and geographic subarea. Table 5.2-7 shows the value of each calibrated constant based on the input observed market shares in Table 5.2-8.

[2] Ibid.

Table 5.2-4: JTW/C Trip Purposes Mode Choice Model

a) Coefficient Values

Variable	Multinomial Model Coefficient	Coefficient for Nested Logit Model					
		Drive Alone Nest	Shared Ride Nest	Transit Access Nest	Walk Sub-modes Nest	Drive Sub-modes Nest	Auxiliary Modes Nest
In-vehicle time	-0.0185	-0.02176	-0.02902	-0.04139	-0.09259	-0.04599	N/A
Terminal time	-0.0370	-0.04353	-0.05804	N/A	N/A	-0.09197	N/A
Operating cost	-0.0031	-0.00365	-0.00486	N/A	N/A	-0.00771	N/A
Parking cost	-0.0031	-0.00365	-0.00486	N/A	N/A	-0.00771	N/A
Walk time	-0.0370	N/A	N/A	-0.08277	-0.18518	-0.09197	-0.03700
Wait time	-0.0318	N/A	N/A	-0.07114	-0.15915	-0.07905	N/A
Transfers	-0.1908	N/A	N/A	-0.42685	-0.95491	-0.47427	N/A
Fare	-0.0031	N/A	N/A	-0.00694	-0.01551	-0.00771	N/A
Nesting Coefficient	N/A	0.8500	0.7500	0.4470	0.4470	0.9000	1.0000

Note: Nested Logit coefficients were determined by dividing the multinomial coefficients by the product of the nesting coefficients. For example, in-vehicle time for the transit drive sub-modes nest was –0.0185 (in-vehicle time coefficient) divided by the product of 0.4470 (transit access nesting coefficient) and 0.9000 (drive sub-modes nesting coefficient).

b) Utility Equations

Shared Ride Equations:

2/car = -0.02902 * in-vehicle time -0.05804 * terminal time -0.00486 * operating cost -0.00486 * parking cost
3+/car = -0.02902 * in-vehicle time -0.05804 * terminal time -0.00486 * operating cost -0.00486 * parking cost + Constants

Highway Equations:

Drive Alone = -0.02176 * in-vehicle time -0.04353 * terminal time -0.00365 * operating cost -0.00365 * parking cost
Shared Ride = 0.7500 * Log Sum of integer car occupancy utiles + Constants

Walk to Transit Sub-mode Equations:

Local Transit = -0.09259 * in-vehicle time -0.18518 * walk time -0.15915 * wait time -0. 95491 * transfers -0.01551 * fare
Premium Transit = -0.09259 * in-vehicle time -0.18518 * walk time -0.15915 * wait time -0. 95491 * transfers -0.01551 * fare + Constants
Guideway Transit = -0.09259 * in-vehicle time -0.18518 * walk time -0.15915 * wait time -0.95491 * transfers -0.01551 * fare + Constants

Drive to Transit Sub-mode Equations:

Park-n-Ride = -0.04599 * in-vehicle time -0.09197 * terminal time -0.00771 * operating cost -0.00771 * parking cost -0.09197 * walk time -0.07905 * wait time -0.47427 * transfers -0.00771 * fare
Kiss-n-Ride = -0.04599 * in-vehicle time -0.09197 * terminal time -0.00771 * operating cost -0.00771 * parking cost -0.09197 * walk time -0.07905 * wait time -0. 47427 * transfers -0.00771 * fare + Constants

Transit Access Equations:

Walk to Transit = 0.4470 * Log Sum of Walk to Transit Sub-mode Utile
Drive to Transit = 0.9000 * Log Sum of Drive to Transit Sub-mode Utile

Auxiliary Equations:

Walk = -0.03700 * walk time
Bike = -0.03700 * bike time + Constants

Highway/Transit/Auxiliary Equations:

Highway = 0.8500 * Log Sum of Drive Alone and Shared Ride Utiles
Transit = 0.4470 * Log Sum of Walk to Transit and Drive to Transit Utiles + Constants
Non-Motorized = 1.0000 * Log Sum of Walk and Bike Utiles + Constants

Note: Constants are by socioeconomic and geographic subarea, as shown in Table 5.2-7.

Table 5.2-5: Other Trip Purposes Mode Choice Model

a) Coefficient Values

Variable	Multinomial Model Coefficient	Coefficient for Nested Logit Model: Drive Alone Nest	Shared Ride Nest	Transit Access Nest	Walk Sub-modes Nest	Drive Sub-modes Nest	Auxiliary Modes Nest
In-vehicle time	-0.0181	-0.02129	-0.02839	-0.04049	-0.09059	-0.04499	N/A
Terminal time	-0.0362	-0.04259	-0.05678	N/A	N/A	-0.08998	N/A
Operating cost	-0.0449	-0.05282	-0.07043	N/A	N/A	-0.11161	N/A
Parking cost	-0.0449	-0.05282	-0.07043	N/A	N/A	-0.11161	N/A
Walk time	-0.0362	N/A	N/A	-0.08098	-0.18117	-0.08998	-0.03620
Wait time	-0.0362	N/A	N/A	-0.08098	-0.18117	-0.08998	N/A
Transfers	-0.2172	N/A	N/A	-0.48591	-1.08704	-0.53990	N/A
Fare	-0.0449	N/A	N/A	-0.10045	-0.22471	-0.11161	N/A
Nesting Coefficient	N/A	0.8500	0.7500	0.4470	0.4470	0.9000	1.0000

Note: Nested Logit coefficients were determined by dividing the multinomial coefficients by the product of the nesting coefficients. For example, in-vehicle time for the transit drive sub-modes nest was –0.0181 (in-vehicle time coefficient) divided by the product of 0.4470 (transit access nesting coefficient) and 0.9000 (drive sub-modes nesting coefficient).

b) Utility Equations

Shared Ride Equations:

2/car = -0.02839 * in-vehicle time -0.05678 * terminal time -0.07043 * operating cost -0.07043 * parking cost
3+/car = -0.02839 * in-vehicle time -0.05678 * terminal time -0.07043 * operating cost -0.07043 * parking cost + Constants

Highway Equations:

Drive Alone = -0.02129 * in-vehicle time -0.04259 * terminal time -0.05282 * operating cost -0.05282 * parking cost
Shared Ride = 0.7500 * Log Sum of integer car occupancy utiles + Constants

Walk to Transit Sub-mode Equations:

Local Transit = -0.09059 * in-vehicle time -0.18117 * walk time -0.18117 * wait time -1.08704 * transfers -0.22471 * fare
Premium Transit = -0.09059 * in-vehicle time -0.18117 * walk time -0.18117 * wait time -1.08704 * transfers -0.22471 * fare + Constants
Guideway Transit = -0.09059 * in-vehicle time -0.18117 * walk time -0.18117 * wait time -1.08704 * transfers -0.22471 * fare + Constants

Drive to Transit Sub-mode Equations:

Park-n-Ride = -0.04499 * in-vehicle time -0.08998 * terminal time -0.11161 * operating cost -0.11161 * parking cost -0.08998 * walk time -0.08998 * wait time -0.5399 * transfers -0.11161 * fare
Kiss-n-Ride = -0.04499 * in-vehicle time -0.08998 * terminal time -0.11161 * operating cost -0.11161 * parking cost -0.08998 * walk time -0.08998 * wait time -0.5399 * transfers -0.11161 * fare + Constants

Transit Access Equations:

Walk to Transit = 0.4470 * Log Sum of Walk to Transit Sub-mode Utile
Drive to Transit = 0.9000 * Log Sum of Drive to Transit Sub-mode Utile

Auxiliary Equations:

Walk = -0. 0362 * walk time
Bike = -0. 0362 * bike time + Constants

Highway/Transit/Auxiliary Equations:

Highway = 0.8500 * Log Sum of Drive Alone and Shared Ride Utiles
Transit = 0.4470 * Log Sum of Walk to Transit and Drive to Transit Utiles + Constants
Non-Motorized = 1.0000 * Log Sum of Walk and Bike Utiles + Constants

Table 5.2-6: NWR-HBK12 Trips Mode Choice Model

a) Coefficient Values

Variable	Multinomial Model Coefficient	Coefficient for Nested Logit Model					
		Drive Alone Nest	Shared Ride Nest	Transit Access Nest	Walk Sub-modes Nest	Drive Sub-modes Nest	Auxiliary Modes Nest
In-vehicle time	-0.0110	-0.01294	-0.01725	-0.02461	-0.05505	-0.02734	N/A
Terminal time	-0.0220	-0.02588	-0.03451	N/A	N/A	-0.05469	N/A
Operating cost	-0.0040	-0.00471	-0.00627	N/A	N/A	-0.00994	N/A
Parking cost	-0.0040	-0.00471	-0.00627	N/A	N/A	-0.00994	N/A
Walk time	-0.0220	N/A	N/A	-0.04922	-0.11011	-0.05469	-0.02200
Wait time	-0.0185	N/A	N/A	-0.04139	-0.09259	-0.04599	N/A
Transfers	-0.1110	N/A	N/A	-0.24832	-0.55553	-0.27591	N/A
Fare	-0.0040	N/A	N/A	-0.00895	-0.02002	-0.00994	N/A
Nesting Coefficient	N/A	0.8500	0.7500	0.4470	0.4470	0.9000	1.0000

Note: Nested Logit coefficients were determined by dividing the multinomial coefficients by the product of the nesting coefficients. For example, in-vehicle time for the transit drive sub-modes nest was –0.0110 (in-vehicle time coefficient) divided by the product of 0.4470 (transit access nesting coefficient) and 0.9000 (drive sub-modes nesting coefficient).

b) Utility Equations

Shared Ride Equations:

2/car = -0.01725 * in-vehicle time -0.03451 * terminal time -0.00627 * operating cost -0.00627 * parking cost
3+/car = -0.01725 * in-vehicle time -0.03451 * terminal time -0.00627 * operating cost -0.00627 * parking cost + Constants

Highway Equations:

Drive Alone = -0.01294 * in-vehicle time -0.02588 * terminal time -0.00471 * operating cost -0.00471 * parking cost
Shared Ride = 0.7500 * Log Sum of integer car occupancy utiles + Constants

Walk to Transit Sub-mode Equations:

Local Transit = -0.05505 * in-vehicle time -0.11011 * walk time -0.09259 * wait time -0.55553 * transfers -0.02002 * fare
Premium Transit = -0.05505 * in-vehicle time -0.11011 * walk time -0.09259 * wait time -0.55553 * transfers -0.02002 * fare + Constants
Guideway Transit = -0.05505 * in-vehicle time -0.11011 * walk time -0.09259 * wait time -0.55553 * transfers -0.02002 * fare + Constants

Drive to Transit Sub-mode Equations:

Park-n-Ride = -0.02734 * in-vehicle time -0.05469 * terminal time -0.00994 * operating cost -0.00994 * parking cost -0.05469 * walk time -0.04599 * wait time -0.27591 * transfers -0.00994 * fare
Kiss-n-Ride = -0.02734 * in-vehicle time -0.05469 * terminal time -0.00994 * operating cost -0.00994 * parking cost -0.05469 * walk time -0.04599 * wait time -0.27591 * transfers -0.00994 * fare + Constants

Transit Access Equations:

Walk to Transit = 0.4470 * Log Sum of Walk to Transit Sub-mode Utile
Drive to Transit = 0.9000 * Log Sum of Drive to Transit Sub-mode Utile

Auxiliary Equations:

Walk = -0. 0220 * walk time
Bike = -0. 0220 * bike time + Constants

Highway/Transit/Auxiliary Equations:

Highway = 0.8500 * Log Sum of Drive Alone and Shared Ride Utiles
Transit = 0.4470 * Log Sum of Walk to Transit and Drive to Transit Utiles + Constants
Non-Motorized = 1.0000 * Log Sum of Walk and Bike Utiles + Constants

Table 5.2-7: Constants Used in the Mode Choice Models

Purpose >	Journey To/From Work (JTW)				Journey At Work (JAW)		Non-Work Related (NWR)				
Constant \/	HBW	HBNW	WB	NB	WB	NB	HBK12	HBCol	HBShp	HBOth	NHB
Level 1- Mode											
K0cbdHwy	0	0	--	--	--	--	0	0	0	0	--
K0cbdTrn	1.305	2.716	0.250	0.250	0.250	0.250	-3.740	29.786	67.725	2.483	--
K0cbdAux	5.346	16.346	--	--	--	--	-3.397	87.097	67.888	17.430	--
K0othHwy	0	0	--	--	--	--	0	0	0	0	--
K0othTrn	2.716	1.351	0.250	0.250	0.250	0.250	62.878	1.062	2.913	2.144	--
K0othAux	3.190	23.318	--	--	--	--	77.959	77.145	3.567	9.498	--
K0elsHwy	0	0	--	--	--	--	0	0	0	0	--
K0elsTrn	3.692	1.407	0.250	0.250	0.250	0.250	3.003	6.505	0.962	4.493	--
K0elsAux	9.090	46.961	--	--	--	--	66.297	66.229	3.614	26.541	--
K1cbdHwy	0	0	0	0	0	0	0	0	0	0	0
K1cbdTrn	0.149	-0.756	-1.873	-1.538	-2.204	-2.542	1.064	1.728	-1.185	-1.397	-0.479
K1cbdAux	3.304	1.187	0.337	-0.196	4.840	77.065	33.335	-0.589	1.748	14.462	-0.383
K1othHwy	0	0	0	0	0	0	0	0	0	0	0
K1othTrn	-0.801	-2.046	-2.300	-1.832	-2.354	-3.344	3.751	-3.868	-2.444	-0.878	-0.688
K1othAux	0.519	-0.762	-0.446	-0.505	0.008	-1.769	7.300	-1.717	-1.007	-0.333	-0.145
K1elsHwy	0	0	0	0	0	0	0	0	0	0	0
K1elsTrn	-0.925	-2.439	-3.253	-3.266	-3.024	-1.946	4.046	0.508	0.115	0.070	-0.450
K1elsAux	4.937	-0.390	-0.069	-0.647	1.272	-0.631	32.590	56.469	1.906	6.049	1.148
K2cbdHwy	0	0	--	--	--	--	0	0	0	0	--
K2cbdTrn	-1.063	-2.750	0.250	0.250	0.250	0.250	0.038	-0.523	-1.784	-2.528	--
K2cbdAux	0.723	-1.872	--	--	--	--	-0.895	-0.623	-2.648	11.137	--
K2othHwy	0	0	--	--	--	--	0	0	0	0	--
K2othTrn	-1.699	-2.689	0.250	0.250	0.250	0.250	-0.473	0.771	-0.944	-0.893	--
K2othAux	-0.516	-2.355	--	--	--	--	-0.008	0.443	0.055	0.498	--
K2elsHwy	0	0	--	--	--	--	0	0	0	0	--
K2elsTrn	-1.880	-3.656	0.250	0.250	0.250	0.250	0.827	-1.712	-2.954	-1.121	--
K2elsAux	0.965	-0.770	--	--	--	--	4.297	57.213	-0.879	2.215	--
Level 2- Highway Shared Ride											
K1o1	0	0	0	0	0	0	0	0	0	0	0
K1sr	-0.924	-0.050	-1.230	0.098	-1.084	-0.416	3.488	-0.914	0.347	0.228	0.529
K2o1	0	0	--	--	--	--	0	0	0	0	--
K2sr	-1.606	-0.183	--	--	--	--	1.589	-1.692	0.056	0.197	--
Level 3- Highway Shared Ride Occupancy											
Kocc2	0	0	0	0	0	0	0	0	0	0	0
Kocc3	-1.214	-0.449	-1.067	-0.616	-0.694	-1.026	0.325	-1.042	-0.227	-0.138	-0.057
Level 2- Transit Access											
K0wacc	0	0	--	--	--	--	0	0	0	0	--
K0dacc	-1.287	-1.249	-3.050	-3.050	-4.050	-2.050	-0.588	-1.793	-1.280	-1.841	--
K1wacc	0	0	0	0	0	0	0	0	0	0	0
K1dacc	3.919	2.155	27.263	1.483	5.204	1.675	-1.253	-0.298	0.390	0.539	3.366
K2wacc	0	0	--	--	--	--	0	0	0	0	--
K2dacc	17.187	-0.312	-1.300	-1.300	-2.300	-0.300	26.932	5.178	3.924	1.607	--
Level 3- Transit Walk Path											
Kngdwy	0	0	0	0	0	0	0	0	0	0	0
Kgdwy	--	--	--	--	--	--	--	--	--	--	--
Kprem	-0.487	-1.163	-0.954	-0.929	-0.527	-0.595	-1.129	-1.505	-0.762	-1.134	-0.790
Level 3- Transit Drive Path											
K1Pnr	0	0	0	0	0	0	0	0	0	0	0
K1Knr	-4.757	-2.529	-26.803	-2.145	-3.674	-1.662	-1.002	-1.531	-1.252	-1.595	-3.433
K2Pnr	0	0	--	--	--	--	0	0	0	0	--
K2Knr	-17.614	-1.760	-0.150	0.750	0.750	-0.250	-27.235	-6.325	-3.595	-2.452	--
Level 2- Auxiliary Path											
Kauxw	0	0	0	0	0	0	0	0	0	0	0
Kauxb	-5.435	-44.147	-3.930	-5.539	-6.704	-80.107	-29.098	-58.261	-4.203	-15.955	-3.988

Notes: 1) Purposes not based at home are not stratified by vehicle ownership—K1 constants apply across all vehicle-ownership strata. 2) "0" represents base constant for that market. 3) "--" indicates cell not applicable.

Table 5.2-8: Observed Shares Used to Calibrate Constants for the Mode Choice Model

Purpose >	Journey To/From Work (JTW)				Journey At Work (JAW)		Non-Work Related (NWR)				
Share \/	HBW	HBNW	WB	NB	WB	NB	HBK12	HBCol	HBShp	HBOth	NHB
Level 1- Mode											
S0cbdHwy	0.13	0.07	--	--	--	--	0.98	0.01	0.01	0.06	--
S0cbdTrn	0.56	0.62	--	--	--	--	0.01	0.45	0.62	0.45	--
S0cbdAux	0.31	0.31	--	--	--	--	0.01	0.54	0.37	0.49	--
S0othHwy	0.05	0.16	--	--	--	--	0.01	0.10	0.11	0.21	--
S0othTrn	0.68	0.24	--	--	--	--	0.37	0.10	0.34	0.29	--
S0othAux	0.27	0.60	--	--	--	--	0.62	0.80	0.55	0.50	--
S0elsHwy	0.21	0.24	--	--	--	--	0.08	0.01	0.55	0.20	--
S0elsTrn	0.66	0.16	--	--	--	--	0.06	0.29	0.08	0.28	--
S0elsAux	0.13	0.61	--	--	--	--	0.86	0.70	0.37	0.52	--
S1cbdHwy	0.49	0.73	0.72	0.78	0.27	0.15	0.24	0.22	0.72	0.67	0.59
S1cbdTrn	0.40	0.15	0.10	0.08	0.03	0.01	0.01	0.77	0.09	0.07	0.16
S1cbdAux	0.11	0.11	0.18	0.15	0.71	0.84	0.75	0.01	0.18	0.25	0.26
S1othHwy	0.68	0.90	0.85	0.87	0.70	0.91	0.38	0.98	0.93	0.87	0.81
S1othTrn	0.16	0.04	0.05	0.05	0.02	0.01	0.18	0.01	0.01	0.05	0.05
S1othAux	0.16	0.06	0.10	0.09	0.27	0.08	0.44	0.01	0.06	0.07	0.14
S1elsHwy	0.80	0.96	0.95	0.97	0.89	0.95	0.42	0.65	0.86	0.84	0.90
S1elsTrn	0.08	0.01	0.01	0.01	0.01	0.01	0.13	0.22	0.04	0.03	0.02
S1elsAux	0.12	0.03	0.04	0.02	0.11	0.04	0.45	0.13	0.10	0.13	0.08
S2cbdHwy	0.77	0.97	--	--	--	--	0.90	0.68	0.91	0.90	--
S2cbdTrn	0.22	0.03	--	--	--	--	0.09	0.31	0.08	0.03	--
S2cbdAux	0.02	0.01	--	--	--	--	0.01	0.01	0.01	0.07	--
S2othHwy	0.88	0.97	--	--	--	--	0.93	0.48	0.88	0.89	--
S2othTrn	0.09	0.02	--	--	--	--	0.04	0.52	0.05	0.04	--
S2othAux	0.03	0.01	--	--	--	--	0.03	0.01	0.07	0.07	--
S2elsHwy	0.92	0.98	--	--	--	--	0.74	0.86	0.98	0.92	--
S2elsTrn	0.05	0.00	--	--	--	--	0.07	0.04	0.00	0.01	--
S2elsAux	0.04	0.02	--	--	--	--	0.19	0.11	0.01	0.07	--
Level 2- Highway Shared Ride											
S1o1	0.66	0.39	0.74	0.37	0.74	0.58	0.01	0.64	0.31	0.33	0.25
S1sr	0.34	0.61	0.26	0.64	0.26	0.42	0.99	0.36	0.70	0.67	0.75
S2o1	0.81	0.42	--	--	--	--	0.06	0.82	0.38	0.34	--
S2sr	0.19	0.58	--	--	--	--	0.94	0.19	0.62	0.67	--
Level 3- Highway Shared Ride Occupancy											
Socc2	0.81	0.62	0.79	0.68	0.72	0.80	0.38	0.77	0.58	0.55	0.52
Socc3	0.19	0.38	0.21	0.32	0.28	0.20	0.62	0.23	0.43	0.45	0.48
Level 2- Transit Access											
S0wacc	0.99	0.99	--	--	--	--	0.93	0.99	0.99	0.99	--
S0dacc	0.01	0.01	--	--	--	--	0.07	0.01	0.01	0.01	--
S1wacc	0.96	0.95	0.82	0.99	0.92	0.99	1.00	0.99	0.98	0.98	0.97
S1dacc	0.05	0.05	0.18	0.01	0.08	0.01	0.00	0.01	0.02	0.02	0.03
S2wacc	0.85	0.99	--	--	--	--	0.85	0.96	0.91	0.97	--
S2dacc	0.15	0.01	--	--	--	--	0.16	0.04	0.10	0.03	--
Level 3- Transit Walk Path											
Sngdwy	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Sgdwy	--	--	--	--	--	--	--	--	--	--	--
Sprem	--	--	--	--	--	--	--	--	--	--	--
Level 3- Transit Drive Path											
S1Pnr	0.38	0.30	0.19	0.19	0.19	0.19	0.30	0.30	0.30	0.30	0.19
S1Knr	0.62	0.70	0.81	0.81	0.81	0.81	0.70	0.70	0.70	0.70	0.81
S2Pnr	0.35	0.30	--	--	--	--	0.30	0.30	0.30	0.30	--
S2Knr	0.65	0.70	--	--	--	--	0.70	0.70	0.70	0.70	--
Level 2- Auxiliary Path											
Sauxw	0.79	0.92	0.94	0.99	0.96	0.99	0.93	0.63	0.92	0.91	0.95
Sauxb	0.21	0.08	0.06	0.01	0.04	0.01	0.07	0.37	0.08	0.09	0.05

Notes: 1) Purposes not based at home are not stratified by vehicle ownership—S1 shares apply across all vehicle-ownership strata. 2) "--" indicates cell not applicable.

Appendix 5-A

Nested Logit Formulations for Journey-to-Work and Home-Based College Purposes

OMPO Mode Choice Estimation
for JTW-* and HBCollege
Nested Logit Structures

Nested Logit Model with 5 modes: SOV, Shared Ride, Transit, Walk, and Bike

Run	Nest	Variable Description	Bias Constants
NEST01	Auto	(ivt + 2*ovt)	Single Modal constants
NEST02	Auto	(ivt + 2*ovt), cost	Single Modal constants
NEST03	Auto	(ivt + 2*walk), (Wait+6*xfer), cost	Single Modal constants
NEST04	Non-motorized	(ivt + 2*ovt)	Single Modal constants
NEST05	Non-motorized	(ivt + 2*ovt), cost	Single Modal constants
NEST06	Non-motorized	(ivt + 2*walk), (Wait+6*xfer), cost	Single Modal constants
NEST07	Non-motorized	(ivt + 2*walk), (Wait+6*xfer), cost	Modal coefficients by Vehicle Ownership (0, 1, 2+)
NEST08	Non-motorized	(ivt + 2*walk), (Wait+6*xfer), cost	Modal coefficients by Vehicle Ownership (0, 1, 2+) and Downtown Destination
NEST09	Non-motorized	(ivt + 2*walk), (Wait+6*xfer), cost	Modal coefficients by Vehicle Ownership (0, 1, 2+) and Downtown/Waikiki Destination

Models for Combined Peak Modeling Purposes

- JTW-HBW
- JTW-HBNW
- JTW-WB
- JTW-NB
- NWR-HBCollege

Table 5-A.1
Nested Logit Formulations for Combined JTW/C Purposes (using unweighted data)

	NEST01				NEST02				NEST03			
	Parameter	Estimate	Std.Error	"T" Ratio	Parameter	Estimate	Std.Error	"T" Ratio	Parameter	Estimate	Std.Error	"T" Ratio
	TIME	-0.0053	0.00047	-11.2	TIME	-0.0058	0.00045	-13.0	TIME1	-0.0064	0.00069	-9.3
									TIME2	-0.0102	0.00152	-6.7
					COST	-0.1830	0.01450	-12.6	COST	-0.1828	0.01450	-12.6
Shared	C_SR	-0.8058	0.02240	-35.9	C_SR	-0.9078	0.02480	-36.6	C_SR	-0.9077	0.02480	-36.6
Ride												
Transit	C_T	-0.1947	0.03500	-5.6	C_T	-0.2114	0.03410	-6.2	C_T	-0.2147	0.03430	-6.3
Walk	C_W	0.0527	0.02890	1.8	C_W	-0.0288	0.02980	-1.0	C_W	-0.0158	0.03180	-0.5
Bike	C_B	-0.6369	0.05630	-11.3	C_B	-0.7008	0.05580	-12.6	C_B	-0.6922	0.05610	-12.3
Non-												
Motorized												
Theta	Auto	3.3870	0.15500	-15.4	Auto	3.6130	0.16000	-16.3	Auto	3.6100	0.16000	-16.3
	Log Likelihood		-8758.3823		Log Likelihood		-8673.5249		Log Likelihood		-8672.9168	
	Rho-Squared (Zero)		0.3061		Rho-Squared (Zero)		0.3128		Rho-Squared (Zero)		0.3129	
	Rho-Squared (Constant)		0.048		Rho-Squared (Constant)		0.0572		Rho-Squared (Constant)		0.0573	
	Value of Time				Value of Time		$ 1.90		Value of Time		$ 2.09	
NOTES:	TIME = IVT + 2*OVT											
	OVT = WalkTime + WaitTime + 6*Transfers											
	TIME1 = IVT + 2*WalkTime											
	TIME2 = WaitTime + 6*Transfers											
	COST in $											
	Selected Formulation is shaded and **BOLD**											

	Table 5-A.1 (continued) Nested Logit Formulations for Combined JTW/C Purposes (using unweighted data)											
	NEST04				NEST05				NEST06			
	Parameter	Estimate	Std.Error	"T" Ratio	Parameter	Estimate	Std.Error	"T" Ratio	Parameter	Estimate	Std.Error	"T" Ratio
	TIME	-0.0213	0.00263	-8.1	TIME	-0.0272	0.00358	-7.6	TIME1	-0.0342	0.00569	-6.0
									TIME2	-0.0450	0.00802	-5.6
					COST	-0.3317	0.05640	-5.9	COST	-0.3491	0.06150	-5.7
Shared	C_SR	-0.9406	0.09410	-10.0	C_SR	-1.3060	0.14300	-9.1	C_SR	-1.3850	0.16400	-8.4
Ride												
Transit	C_T	-1.3920	0.15300	-9.1	C_T	-1.6700	0.18800	-8.9	C_T	-1.7980	0.21900	-8.2
Walk												
Bike	C_B	-2.4240	0.19600	-12.4	C_B	-2.7750	0.22700	-12.2	C_B	-2.9180	0.25300	-11.5
Non-	C_NM	-0.9244	0.11300	-8.2	C_NW	-0.8001	0.12800	-6.2	C_NW	-0.7238	0.13700	-5.3
Motorized												
Theta	Non-Motor	0.9120	0.08790	1.0	Non-Motor	0.7774	0.08190	2.7	Non-Motor	0.7317	0.08400	3.2
	Log Likelihood		-8955.9015		Log Likelihood		-8910.3868		Log Likelihood		-8908.0755	
	Rho-Squared (Zero)		0.2905		Rho-Squared (Zero)		0.2941		Rho-Squared (Zero)		0.2942	
	Rho-Squared (Constant)		0.0265		Rho-Squared (Constant)		0.0315		Rho-Squared (Constant)		0.0317	
	Value of Time				Value of Time		$ 4.93		Value of Time		$ 5.88	
NOTES:	TIME = IVT + 2*OVT											
	OVT = WalkTime + WaitTime + 6*Transfers											
	TIME1 = IVT + 2*WalkTime											
	TIME2 = WaitTime + 6*Transfers											
	COST in $											
	Selected Formulation is shaded and **BOLD**											

Table 5-A.1 (continued)
Nested Logit Formulations for Combined JTW/C Purposes (using unweighted data)

	NEST07				NEST08				NEST09			
	Parameter	**Estimate**	**Std.Error**	**"T" Ratio**	Parameter	Estimate	Std.Error	"T" Ratio	Parameter	Estimate	Std.Error	"T" Ratio
	TIME1	**-0.0255**	**0.00475**	**-5.4**	TIME1	-0.0171	0.00379	-4.5	TIME1	-0.0143	0.00355	-4.0
	TIME2	**-0.0328**	**0.00705**	**-4.7**	TIME2	-0.0156	0.00599	-2.6	TIME2	-0.0077	0.00587	-1.3
	COST	**-0.3108**	**0.05720**	**-5.4**	COST	-0.0957	0.04830	-2.0	COST	-0.0350	0.04800	-0.7
Shared												
Ride					C sr D	0.1557	0.09430	1.7	C sr D	0.2052	0.09480	2.2
									C sr W	0.0934	0.06400	1.5
	C sr 1	**-0.8848**	**0.11500**	**-7.7**	C sr 1	-0.7149	0.09410	-7.6	C sr 1	-0.6875	0.09100	-7.6
	C sr 2	**-1.3350**	**0.15900**	**-8.4**	C sr 2	-1.1180	0.12900	-8.6	C sr 2	-1.0730	0.12400	-8.7
Transit												
					C t D	1.5080	0.20800	7.2	C t D	1.8480	0.24400	7.6
									C t W	0.6479	0.15300	4.2
	C t 0	**2.5800**	**0.38100**	**6.8**	C t 0	1.8140	0.30000	6.0	C t 0	1.3540	0.28200	4.8
	C t 1	**-1.2900**	**0.17800**	**-7.2**	C t 1	-1.7440	0.21300	-8.2	C t 1	-2.0740	0.25100	-8.3
	C t 2	**-2.7310**	**0.32700**	**-8.4**	C t 2	-3.1170	0.35000	-8.9	C t 2	-3.4050	0.37900	-9.0
Walk												
Bike												
	C b 0	**-3.5880**	**0.41900**	**-8.6**	C b 0	-3.5010	0.40600	-8.6	C b 0	-3.4280	0.39900	-8.6
	C b 1	**-2.3590**	**0.24600**	**-9.6**	C b 1	-2.1760	0.23000	-9.5	C b 1	-2.1250	0.22500	-9.4
	C b 2	**-2.8140**	**0.35100**	**-8.0**	C b 2	-2.5790	0.32200	-8.0	C b 2	-2.5050	0.31400	-8.0
Non-												
Motorized	**C nm 0**	**3.7180**	**0.51200**	**7.3**	C nm 0	3.5420	0.46800	7.6	C nm 0	3.4820	0.45700	7.6
	C nm 1	**-0.3475**	**0.14800**	**-2.4**	C nm 1	-0.3578	0.13700	-2.6	C nm 1	-0.3613	0.13400	-2.7
	C nm 2	**-1.5920**	**0.21900**	**-7.3**	C nm 2	-1.5210	0.19800	-7.7	C nm 2	-1.5120	0.19300	-7.8
Theta	**Non-Motor**	**0.8020**	**0.09180**	**2.2**	Non-Motor	0.8742	0.09510	1.3	Non-Motor	0.8990	0.09640	1.0
	Log Likelihood		**-8616.3692**		Log Likelihood		-8561.5154		Log Likelihood		-8550.8945	
	Rho-Squared (Zero)		**0.3174**		Rho-Squared (Zero)		0.3217		Rho-Squared (Zero)		0.3225	
	Rho-Squared (Constant)		**0.0634**		Rho-Squared (Constant)		0.0694		Rho-Squared (Constant)		0.0705	
	Value of Time		**$ 4.92**		Value of Time		$ 10.72		Value of Time		$ 24.53	
NOTES:	TIME = IVT + 2*OVT											
	OVT = WalkTime + WaitTime + 6*Transfers											
	TIME1 = IVT + 2*WalkTime											
	TIME2 = WaitTime + 6*Transfers											
	COST in $											
	Selected Formulation is shaded and **BOLD**											

Table 5-A.2

Final Nested Logit Formulation for Combined JTW/C Purposes Using Weighted Data

	Parameter	Estimate	Std.Error	"T" Ratio
	TIME1	-0.0185	0.00303	-6.1
	TIME2	-0.0318	0.00513	-6.2
	COST	-0.3101	0.04550	-6.8
Shared				
Ride				
	C sr 1	-0.6057	0.07740	-7.8
	C sr 2	-1.0550	0.11300	-9.4
Transit				
	C t 0	2.4980	0.30100	8.3
	C t 1	-0.4714	0.08950	-5.3
	C t 2	-1.5710	0.17400	-9.0
Walk				
Bike				
	C b 0	-3.3500	0.34800	-9.6
	C b 1	-2.1950	0.21900	-10.0
	C b 2	-2.5650	0.30600	-8.4
Non-				
Motorized	C nm 0	2.9620	0.36500	8.1
	C nm 1	-0.1577	0.11600	-1.4
	C nm 2	-1.2450	0.15900	-7.8
Theta	Non-Motor	0.9899	0.10000	0.1
	Log Likelihood		-9181.1859	
	Rho-Squared (Zero)		0.2674	
	Rho-Squared (Constant)		0.0789	
	Value of Time		$ 3.58	
NOTES:	TIME = IVT + 2*OVT			
	OVT = WalkTime + WaitTime + 6*Transfers			
	TIME1 = IVT + 2*WalkTime			
	TIME2 = WaitTime + 6*Transfers			
	COST in $			
	Final Weighted Formulation Based on Unweighted NEST07			

Appendix 5-B

Nested Logit Formulations for Journey-at-Work, Home-Based Shop, Home-Based Other and Non-Home-Based Purposes

OMPO Mode Choice Estimation
for JAW-*, HB Shop, HB Other, and NHB
Nested Logit Structures

Nested Logit Model with 5 modes: SOV, Shared Ride, Transit, Walk, and Bike

Run	Nest	Variable Description	Bias Constants
NEST01	Auto	(ivt + 2*ovt)	Single Modal constants
NEST02	Auto	(ivt + 2*ovt), cost	Single Modal constants
NEST03	Auto	(ivt + 2*walk), (Wait+6*xfer), cost	Single Modal constants
NEST04	Non-motorized	(ivt + 2*ovt)	Single Modal constants
NEST05	Non-motorized	(ivt + 2*ovt), cost	Single Modal constants
NEST06	Non-motorized	(ivt + 2*walk), (Wait+6*xfer), cost	Single Modal constants
NEST07	Non-motorized	(ivt + 2*walk), (Wait+6*xfer), cost	Modal coefficients by Vehicle Ownership (0, 1, 2+)
NEST08	Non-motorized	(ivt + 2*walk), (Wait+6*xfer), cost	Modal coefficients by Vehicle Ownership (0, 1, 2+) and Downtown Destination
NEST09	Non-motorized	(ivt + 2*walk), (Wait+6*xfer), cost	Modal coefficients by Vehicle Ownership (0, 1, 2+) and Downtown/Waikiki Destination
NEST10	Non-motorized	(ivt + 2*ovt), cost	Modal coefficients by Vehicle Ownership (0, 1, 2+)
NEST11	Non-motorized	(ivt + 2*ovt), cost	Modal coefficients by Vehicle Ownership (0, 1, 2+) and Downtown Destination
NEST12	Non-motorized	(ivt + 2*ovt), cost	Modal coefficients by Vehicle Ownership (0, 1, 2+) and Downtown/Waikiki Destination

Models for Combined Other Modeling Purposes

- JAW-WB
- JAW-NB
- NWR-HBShop
- NWR-HBOther
- NWR-NHB

	Table 5-B.1 Nested Logit Formulations for Combined Other Purposes (using Unweighted data)											
	NEST01				NEST02				NEST03			
	Parameter	Estimate	Std.Error	"T" Ratio	Parameter	Estimate	Std.Error	"T" Ratio	Parameter	Estimate	Std.Error	"T" Ratio
	TIME	-0.0040	0.00024	-17.1	TIME	-0.0058	0.00031	-18.9	TIME1	-0.0076	0.00042	-18.3
									TIME2	-0.0046	0.00081	-5.7
					COST	-0.2692	0.01720	-15.7	COST	-0.2501	0.01700	-14.7
Shared Ride	C_SR	0.5151	0.01810	28.5	C_SR	0.4275	0.01980	21.6	C_SR	0.4331	0.01970	22.0
Transit	C_T	0.7320	0.01950	37.6	C_T	0.8147	0.01880	43.4	C_T	0.7743	0.02000	38.7
Walk	C_W	0.8982	0.01480	60.5	C_W	0.8339	0.01600	52.2	C_W	0.8748	0.01590	55.2
Bike	C_B	0.4709	0.02970	15.8	C_B	0.3578	0.03370	10.6	C_B	0.3843	0.03290	11.7
Non-Motorized												
Theta	Auto	8.1130	0.31800	-22.4	Auto	7.6170	0.30700	-21.6	Auto	7.5430	0.30000	-21.8
	Log Likelihood		-12190.0269		Log Likelihood		-12038.0380		Log Likelihood		-11997.6785	
	Rho-Squared (Zero)		0.3483		Rho-Squared (Zero)		0.3564		Rho-Squared (Zero)		0.3586	
	Rho-Squared (Constant)		0.0595		Rho-Squared (Constant)		0.0712		Rho-Squared (Constant)		0.0743	
	Value of Time				Value of Time		$ 1.29		Value of Time		$ 1.83	
NOTES:	TIME = IVT + 2*OVT											
	OVT = WalkTime + WaitTime + 6*Transfers											
	TIME1 = IVT + 2*WalkTime											
	TIME2 = WaitTime + 6*Transfers											
	COST in $											
	Selected Formulation is shaded and **BOLD**											

	NEST04				NEST05				NEST06			
	Table 5-B.1 (continued) **Nested Logit Formulations for Combined Other Purposes (using Unweighted data)**											
	Parameter	Estimate	Std.Error	"T" Ratio	Parameter	Estimate	Std.Error	"T" Ratio	Parameter	Estimate	Std.Error	"T" Ratio
	TIME	-0.0359	0.00339	-10.6	TIME	-0.0470	0.00461	-10.2	TIME1	-0.0806	0.00875	-9.2
									TIME2	-0.0208	0.00765	-2.7
					COST	-0.7627	0.09300	-8.2	COST	-0.8413	0.11100	-7.6
Shared	C_SR	0.5235	0.04350	12.0	C_SR	0.3668	0.04400	8.3	C_SR	0.4521	0.05660	8.0
Ride												
Transit	C_T	-0.7575	0.09830	-7.7	C_T	-0.5613	0.10100	-5.5	C_T	-1.1110	0.15400	-7.2
Walk												
Bike	C_B	-3.4690	0.19000	-18.2	C_B	-3.9670	0.22600	-17.5	C_B	-4.5030	0.28400	-15.9
Non-	C_NM	-0.0357	0.04840	-0.7	C_NW	0.4775	0.08520	5.6	C_NW	1.1040	0.14800	7.4
Motorized												
Theta	Non-Motor	0.9295	0.06890	1.0	Non-Motor	0.7862	0.06470	3.3	Non-Motor	0.6671	0.06190	5.4
	Log Likelihood		-12627.0574		Log Likelihood		-12476.8057		Log Likelihood		-12409.4924	
	Rho-Squared (Zero)		0.3249		Rho-Squared (Zero)		0.3329		Rho-Squared (Zero)		0.3365	
	Rho-Squared (Constant)		0.0258		Rho-Squared (Constant)		0.0374		Rho-Squared (Constant)		0.0425	
	Value of Time				Value of Time		$ 3.70		Value of Time		$ 5.75	
NOTES:	TIME = IVT + 2*OVT											
	OVT = WalkTime + WaitTime + 6*Transfers											
	TIME1 = IVT + 2*WalkTime											
	TIME2 = WaitTime + 6*Transfers											
	COST in $											
	Selected Formulation is shaded and **BOLD**											

	Table 5-B.1 (continued) Nested Logit Formulations for Combined Other Purposes (using Unweighted data)											
	NEST07				NEST08				NEST09			
	Parameter	Estimate	Std.Error	"T" Ratio	Parameter	Estimate	Std.Error	"T" Ratio	Parameter	Estimate	Std.Error	"T" Ratio
	TIME1	-0.0758	0.00859	-8.8	TIME1	-0.0696	0.00801	-8.7	TIME1	-0.0659	0.00767	-8.6
	TIME2	-0.0071	0.00761	-0.9	TIME2	-0.0038	0.00749	-0.5	TIME2	-0.0007	0.00769	-0.1
	COST	-0.6956	0.10300	-6.8	COST	-0.6757	0.10000	-6.8	COST	-0.6719	0.09920	-6.8
Shared												
Ride					C sr D	-0.7632	0.14700	-5.2	C sr D	-0.8800	0.15100	-5.8
									C sr W	-0.5169	0.08140	-6.3
	C sr 1	0.7039	0.08600	8.2	C sr 1	0.7211	0.08600	8.4	C sr 1	0.8390	0.09550	8.8
	C sr 2	0.4516	0.06010	7.5	C sr 2	0.4712	0.06050	7.8	C sr 2	0.5464	0.06600	8.3
Transit												
					C t D	0.6713	0.24000	2.8	C t D	0.7718	0.25600	3.0
									C t W	0.0833	0.18600	0.4
	C t 0	2.6140	0.33600	7.8	C t 0	2.2440	0.31300	7.2	C t 0	1.8960	0.31300	6.1
	C t 1	-1.2470	0.19000	-6.6	C t 1	-1.4540	0.20600	-7.0	C t 1	-1.6090	0.24100	-6.7
	C t 2	-2.6000	0.29700	-8.7	C t 2	-2.7820	0.31100	-8.9	C t 2	-2.9160	0.33100	-8.8
Walk												
Bike												
	C b 0	-6.3420	0.78800	-8.0	C b 0	-6.1800	0.76700	-8.1	C b 0	-6.0910	0.75700	-8.0
	C b 1	-4.2010	0.30700	-13.7	C b 1	-4.1010	0.29800	-13.8	C b 1	-4.0410	0.29300	-13.8
	C b 2	-4.2560	0.32100	-13.3	C b 2	-4.1540	0.31100	-13.3	C b 2	-4.0920	0.30600	-13.4
Non-												
Motorized	C nm 0	4.3870	0.51200	8.6	C nm 0	4.0670	0.48100	8.5	C nm 0	3.7230	0.45400	8.2
	C nm 1	1.2680	0.18000	7.0	C nm 1	1.1180	0.16900	6.6	C nm 1	0.9892	0.16000	6.2
	C nm 2	0.4649	0.13700	3.4	C nm 2	0.3234	0.13100	2.5	C nm 2	0.2153	0.12700	1.7
Theta	Non-Motor	0.6719	0.06390	5.1	Non-Motor	0.6868	0.06460	4.8	Non-Motor	0.6947	0.06490	4.7
	Log Likelihood		-12012.2196		Log Likelihood		-11984.7952		Log Likelihood		-11952.1350	
	Rho-Squared (Zero)		0.3578		Rho-Squared (Zero)		0.3592		Rho-Squared (Zero)		0.3610	
	Rho-Squared (Constant)		0.0732		Rho-Squared (Constant)		0.0753		Rho-Squared (Constant)		0.0778	
	Value of Time		$ 6.54		Value of Time		$ 6.18		Value of Time		$ 5.88	
NOTES:	TIME = IVT + 2*OVT											
	OVT = WalkTime + WaitTime + 6*Transfers											
	TIME1 = IVT + 2*WalkTime											
	TIME2 = WaitTime + 6*Transfers											
	COST in $											
	Selected Formulation is shaded and **BOLD**											

Table 5-B.1 (continued)

Nested Logit Formulations for Combined Other Purposes (using Unweighted data)

	NEST10				NEST11				**NEST12**			
	Parameter	Estimate	Std.Error	"T" Ratio	Parameter	Estimate	Std.Error	"T" Ratio	**Parameter**	**Estimate**	**Std.Error**	**"T" Ratio**
	TIME	-0.0410	0.00425	-9.6	TIME	-0.0371	0.00395	-9.4	**TIME**	**-0.0357**	**0.00394**	**-9.1**
	COST	-0.6297	0.08520	-7.4	COST	-0.6191	0.08370	-7.4	**COST**	**-0.6239**	**0.08420**	**-7.4**
Shared												
Ride					C sr D	-0.7598	0.12300	-6.2	**C sr D**	**-0.8660**	**0.12800**	**-6.8**
									C sr W	**-0.4675**	**0.06790**	**-6.9**
	C sr 1	0.5726	0.06560	8.7	C sr 1	0.5958	0.06630	9.0	**C sr 1**	**0.7086**	**0.07470**	**9.5**
	C sr 2	0.3618	0.04630	7.8	C sr 2	0.3846	0.04700	8.2	**C sr 2**	**0.4562**	**0.05190**	**8.8**
Transit												
					C t D	0.3889	0.19600	2.0	**C t D**	**0.3828**	**0.21000**	**1.8**
									C t W	**-0.1485**	**0.15800**	**-0.9**
	C t 0	2.6040	0.29700	8.8	C t 0	2.2830	0.27900	8.2	**C t 0**	**2.1080**	**0.29000**	**7.3**
	C t 1	-0.6886	0.13300	-5.2	C t 1	-0.8667	0.14300	-6.0	**C t 1**	**-0.8940**	**0.17000**	**-5.3**
	C t 2	-1.7520	0.19400	-9.0	C t 2	-1.9250	0.20500	-9.4	**C t 2**	**-1.9670**	**0.21900**	**-9.0**
Walk												
Bike												
	C b 0	-5.5710	0.67200	-8.3	C b 0	-5.4620	0.65900	-8.3	**C b 0**	**-5.4120**	**0.65500**	**-8.3**
	C b 1	-3.6570	0.25400	-14.4	C b 1	-3.5910	0.24900	-14.4	**C b 1**	**-3.5650**	**0.24800**	**-14.4**
	C b 2	-3.6980	0.26400	-14.0	C b 2	-3.6300	0.25900	-14.0	**C b 2**	**-3.6060**	**0.25800**	**-14.0**
Non-												
Motorized	C nm 0	3.3180	0.36800	9.0	C nm 0	3.0600	0.34700	8.8	**C nm 0**	**2.7900**	**0.33200**	**8.4**
	C nm 1	0.5966	0.11100	5.4	C nm 1	0.4865	0.10500	4.6	**C nm 1**	**0.4088**	**0.10300**	**4.0**
	C nm 2	-0.1289	0.09580	-1.3	C nm 2	-0.2312	0.09560	-2.4	**C nm 2**	**-0.2932**	**0.09710**	**-3.0**
Theta	Non-Motor	0.8036	0.06720	2.9	Non-Motor	0.8173	0.06770	2.7	**Non-Motor**	**0.8191**	**0.06790**	**2.7**
	Log Likelihood		-12079.6138		Log Likelihood		-12046.6715		**Log Likelihood**		**-12011.3589**	
	Rho-Squared (Zero)		0.3542		Rho-Squared (Zero)		0.3559		**Rho-Squared (Zero)**		**0.3578**	
	Rho-Squared (Constant)		0.068		Rho-Squared (Constant)		0.0705		**Rho-Squared (Constant)**		**0.0733**	
	Value of Time		$ 3.90		Value of Time		$ 3.60		**Value of Time**		**$ 3.43**	
NOTES:	TIME = IVT + 2*OVT											
	OVT = WalkTime + WaitTime + 6*Transfers											
	TIME1 = IVT + 2*WalkTime											
	TIME2 = WaitTime + 6*Transfers											
	COST in $											
	Selected Formulation is shaded and **BOLD**											

Table 5-B.2

Final Nested Logit Formulation for Combined Other Purposes Using Weighted Data

	Parameter	Estimate	Std.Error	"T" Ratio
	TIME	-0.0181	0.00231	-7.8
	COST	-4.4910	0.64500	-7.0
Shared Ride				
Transit				
	C t D	0.1111	0.22700	0.5
	C t 0	4.5130	0.52700	8.6
	C t 1	0.7678	0.36900	2.1
	C t 2	-0.1537	0.37800	-0.4
Walk				
Bike	C b D	-1.1510	0.45100	-2.6
	C b 0	-5.5860	0.64600	-8.6
	C b 1	-3.3270	0.24400	-13.7
	C b 2	-3.0740	0.23800	-12.9
Non-Motorized	C b D	0.7773	0.22700	3.4
	C nm 0	2.3170	0.25800	9.0
	C nm 1	-1.1560	0.12700	-9.1
	C nm 2	-1.7800	0.16200	-11.0
Theta	Non-Motor	0.9616	0.07710	0.5
	Log Likelihood		-3641.6551	
	Rho-Squared (Zero)		0.7436	
	Rho-Squared (Constant)		0.2965	
	Value of Time		$ 0.24	

NOTES:
TIME = IVT + 2*OVT
OVT = WalkTime + WaitTime + 6*Transfers
COST in $
Highway cost includes parking cost only (not divided by occupancy)
Final Weighted Formulation Based on Unweighted NEST12

Appendix 5-C

Nested Logit Formulations for Home-Based K–12 School Purpose

OMPO Mode Choice Estimation
for HB K-12 School Journeys
Nested Logit Structures

Nested Logit Model with 5 modes: SOV, Shared Ride, Transit, Walk, and Bike

Run	Nest	Variable Description	Bias Constants
NEST01	Auto	(ivt + 2*ovt)	Single Modal constants
NEST02	Auto	(ivt + 2*ovt), cost	Single Modal constants
NEST03	Auto	(ivt + 2*walk), (Wait+6*xfer), cost	Single Modal constants
NEST04	Non-motorized	(ivt + 2*ovt)	Single Modal constants
NEST05	Non-motorized	(ivt + 2*ovt), cost	Single Modal constants
NEST06	Non-motorized	(ivt + 2*walk), (Wait+6*xfer), cost	Single Modal constants
NEST07	Non-motorized	(ivt + 2*walk), (Wait+6*xfer), cost	Modal coefficients by Vehicle Ownership (0, 1, 2+) at top level
NEST08	Non-motorized	(ivt + 2*walk+2*wait+2*6*xfers), cost	Modal coefficients by Vehicle Ownership (0, 1, 2+) at top level

	Table 5-C.1											
	Nested Logit Formulations for NWR-HBSchool (K-12) Purpose (using Unweighted data)											
	NEST01				NEST02				NEST03			
	Parameter	Estimate	Std.Error	"T" Ratio	Parameter	Estimate	Std.Error	"T" Ratio	Parameter	Estimate	Std.Error	"T" Ratio
	TIME	-0.0002	0.00007	-3.0	TIME	-0.0003	0.00008	-3.5	TIME1	-0.0003	0.00011	-2.8
									TIME2	-0.0005	0.00020	-2.7
					COST	-0.0171	0.00591	-2.9	COST	-0.0171	0.00600	-2.9
Shared	C_SR	2.8830	0.13200	21.9	C_SR	2.8790	0.13200	21.9	C_SR	2.8790	0.13200	21.8
Transit	C_T	2.9160	0.12700	22.9	C_T	2.9240	0.12600	23.2	C_T	2.9240	0.12700	23.1
Walk	C_W	2.9390	0.12400	23.6	C_W	2.9360	0.12400	23.6	C_W	2.9360	0.12500	23.5
Bike	C_B	2.8830	0.13200	21.9	C_B	2.8790	0.13200	21.8	C_B	2.8790	0.13300	21.7
Non-Motorized												
Theta	Auto	48.9500	10.50000	-4.6	Auto	49.1800	10.30000	-4.7	Auto	49.0800	10.60000	-4.5
	Log Likelihood		-1238.6370		Log Likelihood		-1232.7774		Log Likelihood		-1232.7351	
	Rho-Squared (Zero)		0.4070		Rho-Squared (Zero)		0.4098		Rho-Squared (Zero)		0.4099	
	Rho-Squared (Constant)		0.0562		Rho-Squared (Constant)		0.0607		Rho-Squared (Constant)		0.0607	
	Value of Time				Value of Time		$ 1.00		Value of Time		$ 1.06	
NOTES:	TIME = IVT + 2*OVT											
	OVT = WalkTime + WaitTime + 6*Transfers											
	TIME1 = IVT + 2*WalkTime											
	TIME2 = WaitTime + 6*Transfers											
	COST in $											
	Selected Formulation is shaded and **BOLD**											

Table 5-C.1 (continued)

Nested Logit Formulations
for NWR-HBSchool (K-12) Purpose
(using Unweighted data)

	NEST04				NEST05				NEST06			
	Parameter	Estimate	Std.Error	"T" Ratio	Parameter	Estimate	Std.Error	"T" Ratio	Parameter	Estimate	Std.Error	"T" Ratio
	TIME	-0.0131	0.00345	-3.8	TIME	-0.0187	0.00448	-4.2	TIME1	-0.0239	0.00701	-3.4
									TIME2	-0.0297	0.01080	-2.8
					COST	-0.6278	0.29400	-2.1	COST	-0.6474	0.30400	-2.1
Shared	C_SR	3.3840	0.47400	7.1	C_SR	3.4390	0.50800	6.8	C_SR	3.5500	0.54200	6.5
Transit	C_T	2.3730	0.40300	5.9	C_T	2.9050	0.51000	5.7	C_T	2.9920	0.53800	5.6
Walk												
Bike	C_B	-3.0480	0.32600	-9.4	C_B	-3.3190	0.36200	-9.2	C_B	-3.4330	0.39100	-8.8
Non-	C_NM	3.4630	0.48700	7.1	C_NW	3.8890	0.58300	6.7	C_NW	4.1580	0.67400	6.2
Motorized												
Theta	Non-Motor	0.8453	0.11200	1.4	Non-Motor	0.7883	0.10900	1.9	Non-Motor	0.7637	0.10900	2.2
	Log Likelihood		-1266.5774		Log Likelihood		-1260.2488		Log Likelihood		-1259.5994	
	Rho-Squared (Zero)		0.3937		Rho-Squared (Zero)		0.3967		Rho-Squared (Zero)		0.3970	
	Rho-Squared (Constant)		0.0350		Rho-Squared (Constant)		0.0398		Rho-Squared (Constant)		0.0403	
	Value of Time				Value of Time		$ 1.79		Value of Time		$ 2.22	
NOTES:	TIME = IVT + 2*OVT											
	OVT = WalkTime + WaitTime + 6*Transfers											
	TIME1 = IVT + 2*WalkTime											
	TIME2 = WaitTime + 6*Transfers											
	COST in $											
	Selected Formulation is shaded and **BOLD**											

Table 5-C.1 (continued)

Nested Logit Formulations for NWR-HBSchool (K-12) Purpose (using Unweighted data)

	NEST07				NEST08			
	Parameter	**Estimate**	**Std.Error**	**"T" Ratio**	Parameter	Estimate	Std.Error	"T" Ratio
	TIME1	**-0.0143**	**0.00623**	**-2.3**	TIME1	-0.0113	0.00374	-3.0
	TIME2	**-0.0273**	**0.01080**	**-2.5**	TIME2			
	COST	**-0.5705**	**0.30700**	**-1.9**	COST	0.0011	0.00256	0.4
Shared								
	C sr 1	**5.5100**	**1.10000**	**5.0**	C sr 1	5.7160	1.12000	5.1
	C sr 2	**3.3240**	**0.51700**	**6.4**	C sr 2	3.5370	0.54000	6.5
Transit								
	C t 0	**1.9730**	**0.77400**	**2.5**	C t 0	1.5490	0.72000	2.2
	C t 1	**5.4640**	**1.13000**	**4.8**	C t 1	5.2470	1.10000	4.8
	C t 2	**1.9250**	**0.43700**	**4.4**	C t 2	1.7150	0.39800	4.3
Walk								
Bike		**-3.2130**	**0.36500**	**-8.8**		-3.1490	0.34400	-9.2
Non-								
Motorized	**C nm 0**	**4.0840**	**0.91100**	**4.5**	C nm 0	4.0830	0.89400	4.6
	C nm 1	**6.4290**	**1.23000**	**5.2**	C nm 1	6.5790	1.22000	5.4
	C nm 2	**2.9460**	**0.53400**	**5.5**	C nm 2	3.0560	0.50000	6.1
Theta	**Non-Motor**	**0.7687**	**0.11100**	**2.1**	Non-Motor	0.7636	0.10900	2.2
	Log Likelihood		**-1193.5761**		Log Likelihood		-1195.3307	
	Rho-Squared (Zero)		**0.4286**		Rho-Squared (Zero)		0.4278	
	Rho-Squared (Constant)		**0.0906**		Rho-Squared (Constant)		0.0892	
	Value of Time		**$ 1.50**		Value of Time		$ (619.16)	
NOTES:	TIME = IVT + 2*OVT							
	OVT = WalkTime + WaitTime + 6*Transfers							
	TIME1 = IVT + 2*WalkTime							
	TIME2 = WaitTime + 6*Transfers							
	COST in $							
	Selected Formulation is shaded and **BOLD**							

Table 5-C.2

Final Nested Logit Formulation for NWR-HBSchool (K-12) Purpose Using Weighted Data

	Parameter	Estimate	Std.Error	"T" Ratio
	TIME1	-0.0110	0.00516	-2.1
	TIME2	-0.0185	0.00886	-2.1
	COST	-0.3959	0.25600	-1.5
Shared				
	C sr 1	4.9000	1.00000	4.9
	C sr 2	2.6810	0.40600	6.6
Transit				
	C t 0	1.9680	0.60900	3.2
	C t 1	4.5200	0.99600	4.5
	C t 2	1.3470	0.33400	4.0
Walk				
Bike	C b	-3.1020	0.33000	-9.4
Non-				
Motorized	C nm 0	3.5970	0.71700	5.0
	C nm 1	5.5220	1.09000	5.0
	C nm 2	2.2200	0.41300	5.4
Theta	Non-Motor	0.9331	0.13100	0.5
	Log Likelihood		-1158.4643	
	Rho-Squared (Zero)		0.4462	
	Rho-Squared (Constant)		0.1102	
	Value of Time	$	1.66	
NOTES:	TIME = IVT + 2*OVT			
	OVT = WalkTime + WaitTime + 6*Transfers			
	TIME1 = IVT + 2*WalkTime			
	TIME2 = WaitTime + 6*Transfers			
	COST in $			
	Final Weighted Formulation based on Unweighted NEST07			

6. Time-of-Day and Directionality

The time-of-day and directionality model converts trip tables output from the mode-choice model into trip tables usable for network assignment. The mode-choice model considers travel over 24 hours in a production/attraction format. Consequently, four tasks remain that must be accomplished before network-assignment. First, the 24-hour trip tables must be allocated across the individual time-periods of the day. Second, the tables must be converted from production-attraction format to origin-destination format. Third, vehicle trips must be derived from the person-trips-in-private-vehicles estimated for discrete occupancy levels by the mode choice model. Finally, the resulting trips must be aggregated across trip purposes. All of these tasks are accomplished by the Time-of-Day/Directionality model.

6.1 Description

In the trip-based models, outputs from the mode choice procedure include a file of trip-tables for each of the eleven trip purposes. Each of these files comprises ten tables of person-trips – one for each mode covering the entire 24-hour period. The tables are formatted in terms of productions-to-attractions (P>A) rather than origins-to-destinations (O>D) in order to preserve the identification of home and non-home locations. Before the trips in these tables can be assigned to a network, they must be transformed into trips by time-of-day and reformatted to origin-to-destination. These conversions are accomplished with setups that control application of the MINUTP MATRIX and MATFAC programs. Table 6.1-1 summarizes the key features of the Time-of-Day and Directionality Model.

Table 6.1-1

Key Features of the Time-of-Day and Directionality Model

<u>Inputs</u>

- Zone-to-zone trip tables by purpose and mode from the mode choice models

<u>Outputs</u>

- Zone-to-zone trip tables by mode and time of day.
    - Vehicle trips, by occupancy level, for six time periods:

      1 – Morning Peak (6-8 AM)
      2 – Morning Shoulders (5-6 and 8-9 AM)
      3 – Mid-day (9 AM – 2 PM)
      4 – Evening Peak (3-5 PM)
      5 – Evening shoulders (2-3 and 5-6 PM)
      6 – Evening (6 PM to 5 AM).
    - Transit person trip tables, by submode, for two time periods, peak and off-peak

<u>Method</u>

- Factoring based on data from the 1995 Household Interview Survey (HIS).

6.1.1 Vehicle Trips

For each purpose, trips made in the high-occupancy vehicle (HOV) modes (occupancies 2 and 3+ are factored by occupancy to create two HOV vehicle trip-tables.

For each purpose and occupancy, the time-of-day factors in Table 6.1–2 allocate the 24-hour trips across each of six time periods: AM Peak (6–8a), AM Shoulder (5–6,8–9a), Midday (9a–2p), PM Peak (3–5p), PM Shoulder (2–3,5–6p), and Night (6p–5a).

For each purpose, occupancy, and time period, vehicle trips are reformatted to O>D by transposition of the trip matrices and application of the directionality factors shown in Table 6.1–2. Application of both sets of factors occurs simultaneously:

(1) $$T_{OD} = (1 - F_{AP}) * T_{PA} + F_{AP} * T'_{PA}$$

where T_{OD} denotes trips formatted O>D,

T_{PA} denotes trips oriented P>A,

F_{AP} is the fraction of trips oriented A>P, and

T'_{PA} is the transposition of T_{PA} (i.e., trips oriented A>P).

The factors F_{AP} reflect the directional distribution of trips in each time period and by each mode.

For each occupancy and time period, vehicle trips are summed over all purposes. The resulting matrices can be loaded onto a highway network reflecting link characteristics for the appropriate time period. In addition, since separate tables are maintained for SOV, HOV2, and HOV3+ vehicle-trips, assignment to a network including links restricted by occupancy levels can result in different paths for these classes of users.

6.1.2 Person Trips on Transit

For each trip purpose, time-of-day factors convert trips over the 24-hour period into trips in each of two basic time periods. The “peak” period includes the AM peak, the morning shoulder, the PM peak,and the pm shoulder. The “off peak” period assignment includes the mid-day and night periods. These two time period trip matrices are constructed using the factors shown in Table 6.1–2. A separate set of tripmatrices are developed for each of the five basic transit submodes -- walk-to-local-bus, walk-to-premium-bus, walk-to-guideway, kiss-n-ride, and park-n-ride and then assigned to the respective network for the peak and off-peak time periods.

6.2 Development

All factors in Tables 6.1–2 and 6.1–3 have been developed from 1995 Household Interview Survey (HIS) data. The factors are computed directly from cross-tabulations of trips by purpose, mode, and time-of-day.

Computation of the directional factors in Table 6.1–3 required determination of the directionality of each trip in the survey data. Directionality in this case identifies whether the trip is made from production to attraction (P>A) or in the reverse direction (A>P). The factors in Table 6.1–3 describe the proportion of all trips for each purpose and time period that travel in the reverse, or A>P, direction. For example, 2.8 percent of journey-to-work home-based work (JTW-HBW) trips from the HIS travel in the A>P direction during the AM Peak. This means that 97.2 percent of these trips are going from home to work and only 2.8 percent are going from work back to home.

Table 6.1–2: Time-of-Day Factors (Fraction of Trips in Motion by Mode, Purpose, and Time Period)

	JTW-HBW	JTW-HBNW	JTW-WB	JTW-NB	JAW-WB	JAW-NB	HBSch	HBCol	HBShp	HBOth	NHB	Total
SOV												
AM Pk	28.0	10.6	24.6	8.9	5.2		32.0	16.1	3.8	12.2	5.1	17.2
AM Sh	13.3	7.9	9.5	6.3	6.0	2.0	11.3	13.1	5.5	8.5	6.9	9.7
Midday	10.5	11.9	12.1	21.3	60.9	73.8	10.8	38.3	46.0	28.6	56.7	25.9
PM Pk	18.8	17.3	28.1	20.6	12.2	7.7	7.5	8.5	13.9	13.3	11.5	16.8
PM Sh	13.2	17.0	16.5	21.2	11.8	16.4	17.0	10.6	12.7	13.9	10.8	13.7
Night	16.3	35.3	9.3	21.6	3.8		21.4	13.5	18.0	23.4	9.1	16.6
HOV												
AM Pk	29.5	37.9	20.5	20.1	2.9	9.6	59.1	23.3	1.5	13.9	7.2	19.1
AM Sh	13.7	6.7	7.0	4.1	5.2		5.2	12.3	2.2	5.9	3.8	5.8
Midday	6.6	5.2	13.8	9.8	67.0	71.2	3.6	29.8	35.6	21.0	32.2	21.3
PM Pk	19.2	13.7	28.2	24.6	13.2	11.1	10.6	12.5	13.4	14.7	21.5	16.6
PM Sh	12.4	17.0	17.4	18.8	9.3	5.5	19.9	17.5	17.3	17.3	18.7	17.2
Night	18.6	19.6	13.1	22.5	2.3	2.6	1.6	4.6	30.0	27.2	16.7	20.0
Transit												
AM Pk	33.1	8.7	23.0		18.3		55.9	23.8	3.6	8.8	7.8	26.0
AM Sh	12.7	10.7	1.2				4.1	9.6	6.5	8.4	11.9	9.8
Midday	11.7	27.4	10.9	77.1	63.2		2.6	21.2	59.7	40.1	48.0	23.0
PM Pk	20.1	27.7	30.1	3.7	11.9		11.2	18.3	11.7	12.6	15.1	17.2
PM Sh	12.1	13.2	26.5	5.0	6.6		26.1	15.9	14.5	18.1	15.0	15.6
Night	10.2	12.4	8.3	14.2			.1	11.2	3.9	12.0	2.2	8.4
Total												
AM Pk	28.6	26.3	23.4	15.5	4.4	3.3	55.1	18.2	2.3	13.7	6.9	19.1
AM Sh	13.3	7.5	8.6	4.8	4.8	1.0	4.1	13.5	4.2	7.0	4.9	7.6
Midday	9.9	9.1	12.8	15.6	65.8	76.1	4.9	33.2	41.0	24.0	39.1	24.0
PM Pk	19.4	14.9	28.1	22.8	10.6	7.4	9.0	10.6	13.7	14.1	18.3	16.2
PM Sh	13.3	16.7	16.8	19.0	11.5	11.5	25.4	13.2	15.2	16.5	17.1	16.2
Night	15.5	25.5	10.3	22.4	2.9	.9	1.6	11.2	23.6	24.6	13.6	16.8

Table 6.1–3: Directional Distribution Factors F_{AP} (Share of Trips Oriented A>P by Purpose and Time Period)

	AM Pk (6-8a)	AM Sh (5-6,8-9a)	Midday (9a-2p)	PM Pk (3-5p)	PM Sh (2-3,5-6p)	Night (6p-5a)	Total
NWR: Home-Based Other	.204	.277	.363	.488	.522	.610	.440
NWR: Non-Home-Based	.000	.000	.000	.000	.000	.000	.000
NWR: Home-Based Shopping	.135	.208	.530	.634	.634	.621	.559
JTW: Home-Based Work	.028	.039	.325	.885	.836	.748	.444
JTW: Home-Based Non-Work	.003	.018	.453	.897	.919	.935	.569
JTW: Work-Based Non-Home	.014	.048	.492	.921	.876	.814	.560
JAW: Work-Based	.492	.578	.538	.767	.741	.710	.591
JTW: Non-Based	.000	.000	.000	.000	.000	.000	.000
JAW: Non-Based	.000	.000	.000	.000	.000	.000	.000
NWR: Home-Based K-12 School	.002	.016	.657	.845	.795	.758	.324
NWR: Home-Based College	.005	.033	.397	.633	.848	.849	.411
Total	.058	.119	.327	.596	.583	.589	.389

D. Other Transportation Models

1. Airport Access Trips

1.1 Description

The airport access trip procedures estimate vehicle trips generated by air travelers, to and from the airport. The estimation procedure consists of a trip generation step, a distribution step and a mode choice/time of day step.

1.2 Trip Generation

The trip generation step estimates trip ends for three “purposes” – resident air passenger trips, visitors on tours trips, and independent visitor air passenger trips. The number of daily trips[1] for these three purposes is an exogenous variable and for the calibration year was: (1) 10,000 residential trips; (2) 16,000 visitors on tour trips; and (3) 34,000 independent visitor trips.

1.3 Trip Distribution

The distribution model is simply an allocation process for build trip tables from the trip ends since all the non-airport trip ends are “anchored” to the airport trip ends. At the non-airport end of the trip the resident trips are distributed according to the number of households in the zone; the visitors on tour are distributed according to the number of hotel rooms in the zone; and the independent visitors are distributed according to households (a weight of 1) and hotels rooms (a weight of 25). A generalized form of this distribution function is as follows:

$$AP_{i,p} = TAP * \frac{B_p * X_p}{\sum_i B_p * X_p}$$

where:

$Ap_{i,p}$ = the number of Air Passengers located in zone “i” for trip purpose “p”;

TAP = the total number of Air Passengers for trip purpose “p”;

B_p = coefficient or weight on variable X_p;

X_p = Independent Variable (such as households or hotel rooms).

1.4 Mode Choice

The mode choice procedure is more detailed. The mode choice consists of a number of average uses by mode.

[1] These control totals are based upon statisitics published in “The State of Hawii Data Book for 1995”, Department of Business, Economic Development & Tourism, State of Hawaii, Table 18.41.

For resident travelers these assumptions are:

1. That 80 percent of the resident air travelers will come by private automobile, with half parking at the airport and half being dropped off.
    a. The average car occupancy for these trips (air passengers per vehicle) is 1.5
    b. That the drop off trips require 2 trips (one from the airport and one to the airport)
2. That 15 percent of the resident air travelers will come by taxi
    a. The average car occupancy (air passengers) for these trips will be 2.0
    b. That the trips will require 2 trips (one to and one from the airport)
3. That 5 percent of the resident air travelers will come by shuttle van
    a. The average car occupancy for these trips will be 4.0
    b. The trips will require 2 trips (one to and one from the airport)

For independent visitors the assumptions are:

1. That 25 percent of the independent visitors will come by private automobile
    a. The average car occupancy for these trips (air passengers per vehicle) is 2.0
    b. The trips will require 2 trips
2. That 25 percent of the independent visitors will come by taxi
    a. The average car occupancy for these trips is 2.0
    b. The trips will require 2 trips
3. That 50 percent of the independent visitors will come by shuttle van
    a. The average occupancy will be 4
    b. The trips will require 2 trips

For visitors on tours the assumptions are:

1. That 25 percent of the visitors on tour will come by shuttle van
    a. The average occupancy for these trips (air passengers per vehicle) is 4.0
    b. The trips will require 2 trips
2. That 75 percent of the visitors on tour will come by tour bus
    a. The average occupancy for these trips is 15.0

b. The trips will require 2 trips

The occupancy is used to estimate the number of vehicle trips, which is the air passenger trips divided by the occupancy. Therefore taxi, shuttle van and tour buses are included in the vehicle trip table.

1.5 Time of Day

The time of day procedure is very simple. Thirty percent of the trips are assumed to take place in the morning peak period (from 5 to 9 AM), thirty percent of the trips are assumed to take place in the evening peak period (from 2 to 6 PM), and forty percent of the trips are assumed to take place in the off-peak hours (all other hours).

2. Visitor Trips

The visitor trip estimation procedure utilizes a Visitor Model developed for the Honolulu Rapid Transit Program[1]. This model was calibrated using existing visitor travel pattern data collected in a survey of departing Oahu visitors conducted for that purpose[2]. The visitor survey was conducted during August 1991 at Honolulu International Airport in or near departure gates. A sample of flights was selected to reflect the distribution of flights scheduled to depart Honolulu for all overseas destinations in a given week. The survey was not intended to gather complete information on the full extent of visitor travel made during a stay on Oahu, nor to gather information regarding visits to neighbor islands, nor to list every conceivable destination a visitor might consider on Oahu. Rather, the survey instrument was focused exclusively on the travel characteristics and behavior of visitors with respect to 25 strategically important visitation sites.

The Visitor Model utilizes a nested logit structure to simultaneously estimate the frequency/destination and mode choice of visitors traveling from hotels or resort condos to the 25 key destinations listed below.

Ala Moana Park	Kodak Hula Show
Ala Moana Center	Pearl Harbor
Aloha Stadium	Arizona Memorial
Aloha Tower	Pearlridge Center
Bishop Museum	Polynesian Cultural Center
Chinatown	Punchbowl National Cemetery
Diamond Head	Royal Hawaiian Shopping Center
Dole Cannery Square	US Army Museum – Fort DeRussy
Central Business District	University of Hawaii
Hanauma Bay	Waikiki Aquarium
Honolulu Zoo	Waikiki Beaches
International Marketplace	Waimea Falls Park
Iolani Palace	

The model predicts visitor travel for the following six modes[3]: Auto, Local Bus, Premium or Guideway Transit (Rapid Bus or Rail), Taxi, Tour Bus, and Walk.

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[1] "Task 3.03 Service and Patronage Forecasting Methodology," Prepared for the Department of Transportation Services, Office of Rapid Transit, City and County of Honolulu, Prepared by Barton-Aschman Associates, Inc. and Parsons Brinckerhoff Quade & Douglas, Inc., March 1992.

[2] "Task 3.2 Oahu Visitors Travel Survey Final Report," Prepared for the Department of Transportation Services, Office of Rapid Transit, City and County of Honolulu, Prepared by Barton-Aschman Associates, Inc., January 1992.

[3] For the Honolulu Rapid Transit Program only visitor travel by transit was reported.

2.1 Frequency/Destination Nest

The Visitor Model treats each destination independently. The top level of the nesting structure is a frequency/destination nest, which determines the share of visitors who will decide to travel to each of the destinations. The decision is between making a trip, and not making a trip. The utility equations for the Trip and No Trip choices are shown in Equations 1 and 2 below.

(1) $$U_{NoTrip} = 0$$

(2) $$U_{Trip} = \beta_{LogSum} \cdot LogSum + \beta_1 \cdot Dummy1 + \beta_2 \cdot Dummy2 + \ldots + \beta_{25} \cdot Dummy25$$

The "LogSum" variable is calculated using the equations in the mode choice-level nest. The LogSum is defined as the natural log of the sum of the exponents of each modal utility (see Equation 9 in the following section, 2.2).

The "Dummy" variables take a value of 1 or 0. As mentioned previously, the 25 destinations are treated independently in the model. When applying the model to destination number 1, Dummy1 is 1 and Dummy2 – Dummy25 are 0. Similarly, when applying the model to destination number 2, Dummy2 is 1 and all other Dummy variables are 0.

The Model coefficients are shown in Table 2.1.

Table 2.1
Frequency/Destination Nest Model Coefficients

Coefficient	Destination Number	Value
LogSum		0.21710
Ala Moana Park	1	-2.23384
Ala Moana Center	2	-0.78665
Aloha Stadium	3	-3.03093
Aloha Tower	4	-3.50281
Bishop Museum	5	-3.95056
Chinatown	6	-2.71094
Diamond Head	7	-1.76370
Dole Cannery Square	8	-2.43372
Central Business District	9	-1.89066
Hanauma Bay	10	-1.78691
Honolulu Zoo	11	-3.50003
International Marketplace	12	-0.39423
Iolani Palace	13	-3.18971
Kodak Hula Show	14	-3.83589
Pearl Harbor	15	-1.85926
Arizona Memorial	16	-2.21412
Pearlridge Center	17	-3.54949
Polynesian Cultural Center	18	-2.32195
Punchbowl National Cemetery	19	-2.18386
Royal Hawaiian Shopping Center	20	-1.75141
US Army Museum – Fort DeRussy	21	-4.65630
University of Hawaii	22	-3.52679
Waikiki Aquarium	23	-3.84432
Waikiki Beaches	24	0.44617
Waimea Falls Park	25	-2.43219

These coefficients have been re-calibrated since the original Honolulu Rapid Transit model development effort. The re-calibration was necessitated by the change in zonal system along with improvements and updates to the transportation network and insured that the transit estimates match the observed ridership of transit trips going to the 25 key destinations.

2.2 Mode-Level Nest

A straightforward mode choice model is used to determine the mode of the visitors. The model considers auto, local bus, premium transit (rapid bus or rail), taxi, tour bus, and walk and uses a multinomial logit formulation.

The utility equations for each mode are shown in the Equations below.

(3) $$U_{auto} = \beta_{auto} + \beta_1 \cdot (\text{ivtt}) + \beta_2 \cdot (\text{ovtt}) + \beta_3 \cdot (\text{auto operating cost}) + \beta_4 \cdot (\text{parking cost})$$

(4) $$U_{bus} = \beta_{transit} + \beta_1 \cdot (\text{ivtt}) + \beta_2 \cdot (\text{ovtt}) + \beta_3 \cdot (\text{fare})$$

(5) $$U_{premiumTransit} = \beta_{transit} + \beta_1 \cdot (\text{ivtt}) + \beta_2 \cdot (\text{ovtt}) + \beta_3 \cdot (\text{fare})$$

(6) $$U_{taxi} = \beta_{taxi} + \beta_1 \cdot (\text{ivtt}) + \beta_2 \cdot (\text{ovtt}) + \beta_3 \cdot (\text{fare})$$

(7) $$U_{tour} = \beta_{tour} + \beta_1 \cdot (\text{ivtt}) + \beta_2 \cdot (\text{ovtt}) + \beta_3 \cdot (\text{tour cost}) + \beta_7 \cdot (\text{tour dummy})$$

(8) $$U_{walk} = \begin{cases} \text{if ovtt} < 20\text{ mins}: \beta_{walk} + \beta_5 \cdot (\text{ovtt}) \\ \text{if ovtt} \geq 20\text{ mins}: \beta_{walk} + \beta_6 \cdot (\text{ovtt}) \end{cases}$$

Table 2.2, below, summarizes the estimated coefficients. As mentioned in Section 2.1, the Alternative-specific constants have been recently re-calibrated. The “Premium Transit” mode was not present in the estimation/calibration year transit environment. As a result, the bias constant specific to Premium Transit is set equal to that of Local Bus.

Table 2.2
Frequency/Destination Nest Model Coefficients

Coefficient	Value
Alternative-specific constant – Auto Mode (β_{auto})	-1.95361
Alternative-specific constant – Transit Mode ($\beta_{transit}$)	-5.05137
Alternative-specific constant – Taxi Mode (β_{taxi})	-6.29218
Alternative-specific constant – Tour Mode (β_{tour})	-4.53682
Alternative-specific constant – Walk Mode (β_{walk})	0.0000
In-vehicle travel time (minutes) (β_1)	-0.02712
Out-of-vehicle travel time (minutes) (β_2)	-0.05424
Operating Cost (cents) (β_3)	-0.003816
Parking Cost (cents) (β_4)	-0.007776
Walk time less than 20 minutes (β_5)	-0.05424
Walk time more than 20 minutes (β_6)	-0.13220
Tour Dummy (β_7)	1.30300

The Mode Choice LogSum can be calculated from the Utility expressions shown in Equations 3 – 8. The LogSum is used as a variable in the Frequency/Destination nest of the Visitor Model. Such a formulation allows the probability of a visitor traveling to a specific destination to increase if the accessibility between the origin and destination increases. The LogSum expression is shown in Equation 9.

(9) $$LogSum = \ln\left[\exp(U_{auto}) + \exp(U_{bus}) + \exp(U_{premiumTransit}) + \exp(U_{taxi}) + \exp(U_{tour}) + \exp(U_{walk})\right]$$

2.3 Visitor Trips to Other Destinations

The visitor model only captures travel to the 25 key destinations listed in Table 2.1. These twenty-five destinations, however, capture a vast majority of visitor travel on the island, in excess of 90% of all such travel. The 1991 On-Board Transit Rider Survey[4] provided the opportunity to consider all of the remaining non-resident visitor transit trips to all other destinations. An observed trip table[5], of non-permanent Oahu residents, was developed for destinations other than the 25 key destinations. This observed trip table is added to the transit trips produced by the Visitor Model. Therefore, non-transit visitor trips to other destinations are not included in the model. Without a comprehensive data base that includes this segment of visitor travel, it was not possible to develop a model or trip matrix of these trips. Fortunately, the magnitude of this visitor travel is minimal.

In forecasting, the on-board survey-based transit trip table can be grown to account for increases in travel. Because these trips represent all types of travel by non-residents of Oahu (i.e., students going to school, part-time residents going to work or to the market), a growth factor must be chosen carefully. A suggested growth factor is the overall increase in transit ridership from the base year to the forecast year.

2.4 Time-of-Day Factoring

The Visitor Model is calibrated to produce daily trips. To assign these trips to highway and transit networks, they must be converted to AM Peak, Off-Peak, and PM Peak trips.

For the transit assignment, factors were developed from the On-Board Survey data, which indicated approximately 46 percent of the trips traveled during the Peak periods and 54 percent traveled during the Off-Peak periods. It was assumed that 30 percent of the Visitors traveling during the Peak would do so during the AM Peak Period and 70 percent during the PM Peak Period. This led to the following factors:

- AM Peak – 0.14
- Off-Peak – 0.54
- PM Peak – 0.32

For auto trips, the Home-based Other time-of-day factors from the resident models were used to distribute the Visitor auto and taxi trips throughout the day. The non-resident visitor survey did not obtain time of day information, therefore, the diurnal patterns assumed for auto and taxi trips were assumed to mirror those of resident travel:

- AM Peak – 0.21
- Off-Peak – 0.52
- PM Peak – 0.27

[4] Task 3.01, "On Board Bus Survey Final Report", Honolulu Rapid Transit Program, prepared for Department of Transportation Services, Office of Rapid Transit, The City and County of Honolulu, prepared by Barton-Aschman Associates, Inc., March 1992.

[5] The observed On-Board survey based trip table is named "VISTRN.OBS" and is located in the VIS subdirectory.

3. Truck Trips

3.1 Description

The truck estimation procedure estimates truck trips for seven “purposes”. These purposes are:

1. Garage-Based Two Axle Truck Trips
2. Garage-Based Three Axle Truck Trips
3. Garage-Based Four Axle Truck Trips
4. Non-Garage-Based Two Axle Truck Trips
5. Non-Garage-Based Three Axle Truck Trips
6. Non-Garage-Based Four Axle Truck Trips
7. Port-Based Truck Trips

The truck trip estimation procedures consist of a trip generation step, a trip distribution step, and a time of day step.

3.1.1 Trip Generation

The trip generation procedure is a set of truck trip rates for different types of employment. These trip rates are shown on Table 1–1. For the Garage-Based Truck trips, there are a set of trip rates for the production (origin) end of the trip and a separate set for the attraction (destination) end of the trip. For the Non-Garage-Based Truck trips, a single set of rates (trips ends per employment) are used. These rates are for both the productions (origin) trip rates and the attraction (destination) trip rates. For the Port-Based Truck trips, the productions (the trip ends at the Port zones) are an exogenous input, while the attractions (trips ends at the non-port zones) are estimated using trip rates by employment. For the base year, the Port-Based Truck trips were specified as 6,310 daily truck trips – with the truck trips distribute evenly disbursed between the six “port” zones (which were 234, 330, 331, 332, 347, and 350). The attraction rates and the attractions for the Garage-Based Truck trips and the Port-Based Truck Trips are used only to allocate the total truck trips to the various traffic analysis zones – the production rates and productions for these purposes “set” the total number of truck trips.

Table 1–1
Truck Trip Rates

Employment Category	Production (Origin) Trip Rate per Employee:					
	Garage-Based Trucks with:			Non-Garage-Based Trucks with:		
	Two Axles	Three Axles	Four Axles	Two Axles	Three Axles	Four Axles
Total	0.0000	0.0000	0.0000	0.0324	0.0039	0.0073
Military	0.0460	0.0037	0.0084	0.0000	0.0000	0.0000
Government	0.0460	0.0037	0.0084	0.0000	0.0000	0.0000
Hotel	0.0460	0.0037	0.0084	0.0000	0.0000	0.0000
Agriculture	0.0460	0.0037	0.0084	0.0000	0.0000	0.0000
Transportation	0.0460	0.0037	0.0084	0.0000	0.0000	0.0000
Industry	0.0110	0.0014	0.0044	0.0000	0.0000	0.0000
Fiscal	0.0460	0.0037	0.0084	0.0000	0.0000	0.0000
Service	0.0105	0.0000	0.0027	0.0000	0.0000	0.0000
Retail	0.0140	0.0012	0.0000	0.0000	0.0000	0.0000
Construction	0.0460	0.0037	0.0084	0.0000	0.0000	0.0000

Note: Port-Based Truck Productions is an exogenous variable, developed outside the trip generation model.

Employment Category	Attraction (Destination) Trip Rate per Employee:			
	Garage-Based Trucks with:			Port-Based
	Two Axles	Three Axles	Four Axles	
Total	0.0234	0.0000	0.0000	0.0000
Military	0.0000	0.0046	0.0136	0.0014
Government	0.0000	0.0046	0.0136	0.0014
Hotel	0.0000	0.0046	0.0136	0.0014
Agriculture	0.0000	0.0046	0.0136	0.0014
Transportation	0.0000	0.0046	0.0136	0.0014
Industry	0.0000	0.0046	0.0136	0.0000
Fiscal	0.0000	0.0046	0.0136	0.0014
Service	0.0000	0.0000	0.0000	0.0000
Retail	0.0000	0.0000	0.0000	0.0000
Construction	0.0000	0.0046	0.0136	0.0014

Note: The Non-Garage-Based Truck attractions are equal to the Non-Garage-Based Truck Productions

3.1.2 Trip Distribution

There is a distribution model for each truck trip purpose. The distribution model is a logit model with the same formulation as the residential trip purposes[1]. The impedance measure for these models is the peak period highway travel times. The logit model's coefficients (P1 and P2) are the same for all the truck purposes and the P1 coefficient value is –0.03 while the P2 coefficient value is 0.00.

[1] Refer to page C.4-1, and C-4.3 for a detailed mathematical description of the logit form of the distribution model and the corresponding impedance function formulation.

3.1.3 Time of Day

The truck time of day procedure is very simple. Thirty percent of the truck trips take place in the morning peak period (from 5 to 9 AM), thirty percent of the trips take place in the evening peak period (from 2 to 6 PM), and forty percent of the trips take place in the off-peak hours (all other hours).

The final step in the procedure is to add all the seven purpose to a single truck trip purpose (actually three trip tables – one per time period) for use in the highway assignment process.

3.2 Development

The truck trip forecasting procedures are borrowed from the San Francisco Bay area:

> "Truck Travel in the San Francisco Bay Area." I-880 Intermodal Corridor Study. Prepared for Caltrans District 4 and Alameda County. Prepared by Barton-Aschman Associates, Inc. December 1992.

E. Validation of the Travel Models

Validation of the Travel Models

The regional travel models were applied using land use data and transportation networks representing 1995-96 conditions. The trips estimated from these models were assigned to their respective networks. That is, automobile and truck trips were assigned to the highway network and transit trips were assigned to the transit network. The highway roadway volumes, estimated in the assignment procedure, were compared to traffic analysis counts for seventeen screenlines and summary statistics, the Root Mean Square measurement, were calculated for 507 highway roadway links. The estimated vehicle miles of travel were compared to the vehicle miles developed from the 1995 Highway Performance Monitoring System (HPMS). The estimated transit route boardings were compared to route boardings from the 1991 On-Board survey.

1 Highway Assignment Validation

Three highway assignments are performed by the model: a morning peak period assignment, an evening peak period assignment and a non-peak, or off-peak, period assignment. The highway vehicle trips were assigned to the highway network using the MINUTP equilibrium capacity constraint procedures with a maximum of 30 iterations for the morning and evening peak period assignments. The off-peak period assignment was a single pass "all or nothing" assignment. For reporting purposes the volumes from the three assignments were added together to produce a daily assignment.

An important part of the highway assignment process is the volume-delay function. This function uses the free-flow speed, capacity and estimated volume of a highway link to estimate the probable speed of the link. The volume delay function is applied for each iteration, for each link, to estimate probable congested speed to be used for the next iteration. The volume delay function used in this study was developed from work performed by Rupinder Singh of the Metropolitan Transportation Commission of the San Francisco/Oakland area, based on a speed-flow model originally developed by Rahmi Ak elik [1]. The Akçelik speed-flow model has the mathematical formulation of:

$$t = t_o + \{0.25T[(x-1) + \{(x-1)^2 + (8J_a x/QT)\}^{0.5}]\}$$

where:

t = average travel time per unit distance (hours/mile)
t_o = free-flow travel time per unit distance (hours/mile)
T = flow period, i.e., the time interval in hours, during which an average arrival (demand) flow rate, v, persists
Q = Capacity
x = the degree of saturation i.e., v/Q
J_a = the delay parameter

[1] "Improved Speed-Flow Relationships: Application to Transportation Planning Models", by Rupinder Singh, Associate Transportation Planner, Metropolitan Transportation Commission. Paper presented at the 7th TRB Conference on Application of Transportation Planning Methods, Boston Massachusetts, March 1999.

For the Honolulu (OMPO) model there were different delay parameters by facility type. These delay (J_a) parameters were:

Freeways, Expressways, and High speed Ramps – 0.8
Arterial I – 1.6
Arterial II and III – 3.2
Collector I – 6.4
Collector II, Local Streets, and Low Speed Ramps – 12.8
Centroid Connectors – No adjustment made to these links

Also important for the assignment procedures are the free-flow speed and the capacity per lane of the roadways. This model assigned free-flow speed and capacities to the roadways based on the facility type and the area type. The free-flow speeds and capacities used in the model are presented in Table 1.

Table 1a
Free Flow Speed (Miles per Hour) by Facility type and Area Type

Facility Type	Area Type							
	CBD	Core Comm.	Core Res.	Urban Comm.	Urban Res.	Sub. Comm.	Sub. Res.	Rural
Freeway	60	63	63	65	65	68	68	68
Expressway	54	57	58	59	60	60	61	61
Arterial I	34	35	35	37	37	41	45	47
Arterial II	30	32	32	34	35	40	42	47
Arterial III	28	30	30	32	33	37	40	47
Collector I	26	28	28	30	30	35	39	46
Collector II	24	26	27	28	28	33	38	45
Local St.	12	17	18	19	20	25	30	32
High Speed Ramps	50	50	51	51	52	52	55	57
Low Speed Ramps	25	30	30	30	30	35	35	37
Centroids Connectors	12	17	18	19	20	25	30	32

Table 1b
Capacity (vehicles per lane per hour) by Facility type and Area Type

Facility Type	Area Type							
	CBD	Core Comm.	Core Res.	Urban Comm.	Urban Res.	Sub. Comm.	Sub. Res.	Rural
Freeway	2,200	2,200	2,200	2,200	2,200	2,200	2,200	2,200
Expressway	1,500	1,550	1,550	1,550	1,600	1,650	1,750	1,850
Arterial I	1,100	1,100	1,150	1,150	1,200	1,300	1,400	1,450
Arterial II	1,050	1,050	1,100	1,100	1,150	1,200	1,250	1,350
Arterial III	1,000	1,050	1,050	1,050	1,100	1,150	1,200	1,300
Collector I	850	850	850	850	900	950	1,000	1,050
Collector II	650	700	700	700	750	800	850	950
Local St.	650	700	700	700	750	800	850	950
High Speed Ramps	1,600	1,700	1,800	1,800	1,900	1,900	2,000	2,000
Low Speed Ramps	400	400	450	450	500	500	600	650
Centroid Connectors	3,150	3,150	3,150	3,150	3,150	3,150	3,150	3,150

The total average weekday vehicle miles of travel (VMT) are shown on Table 2. It is estimated that slightly over twelve million VMT occurred in the region in 1995. Of this all most half was on limited access roadways (freeways and expressways). A comparison with the 1995 VMT from the Highway Performance Monitoring System (HPMS) showed that the two VMTs were different by eight percent. When the estimated VMT is compared to the HPMS VMT by type of roadways, the model tends match VMT on the limited access roads (freeways and expressways) very closely and under-estimate the major arterials by 17 percent. The minor arterials appear to be under-estimated by 46 percent while collectors and local roads are over-estimated by 20 percent. This may be a slight problem in definitions, with some roads the model group had designated as collectors being specified as minor arterials in the HPMS data. This comparison with HPMS data is very good and indicates that the model is producing reasonable regional vehicle miles of travel.

Table 2a
Comparison of Observed and Estimated Daily Vehicle Miles of Travel by Highway Group

	Estimated Daily VMT	Observed Daily VMT *	Difference	Percent Difference
Freeways (1,2,9, and 10)	5,962,831	5,948,045	14,786	0.2%
Principal Arterial (3 and 4)	2,778,320	3,352,981	-574,661	-17.1%
Minor Arterial (5 and 6)	842,365	1,554,551	-712,186	-45.8%
Collector, Local (7, 8, and 12)	1,590,220	1,327,428	262,792	19.8%
Total	11,173,736	12,183,005	-1,009,269	-8.3%
Minor and Collector	2,432,585	2,881,979	-449,394	-15.6%

- The observed VMT is from the 1995 HPMS data

Table 2b
Estimated Daily Vehicle Miles of Travel (VMT)
by Facility Type

Facility Type	Daily VMT	Percent of Total
1 – Freeways	4,177,320	37.38%
2 – Expressways	1,460,012	13.06%
3 – Class I Arterials	1,529,138	13.69%
4 – Class II Arterials	1,249,182	11.18%
5 – Class III Arterials	425,136	3.80%
6 – Class I Collectors	417,229	3.73%
7 – Class II Collectors	606,415	5.43%
8 – Local Streets	184,194	1.65%
9 – High Speed Ramps	215,413	1.93%
10 – Low Speed Ramps	110,086	0.99%
12 – Centroid Connectors	799,611	7.16%
All Links	11,173,730	100.00%

A total of 17 screenlines were reviewed in the analysis. The total number of daily vehicles crossing the screenlines was approximately three million. The difference between the observed counts and the estimated counts, for individual screenlines, ranged from 4.0 percent to 84.6 percent. The larger screenlines, those with more than 300,000 vehicles, had errors ranging from 4 percent to 20 percent. In general the estimated screenline volumes agreed with the observed screenline volumes. The observed and estimated daily traffic for these seventeen screenlines is shown in Table 3.

Table 3
Comparison of Daily Counts versus Assigned Volumes for Seventeen Screenlines

Screen Line	Count	Assigned Volume	Difference	Percent Difference
1	42,129	37,277	-4,852	-11.52%
2	175,588	123,075	-52,513	-29.91%
3	18,338	2,819	15,519	-84.63%
4	120,069	105,115	-14,954	-12.45%
5	313,844	251,877	-61,967	-19.74%
6	353,463	339,175	-14,288	-4.04%
7	406,541	331,865	-74,676	-18.37%
8	431,348	345,650	-85,698	-19.87%
9	382,953	331,653	-51,300	-13.40%
10	379,927	302,048	-77,879	-20.50%
11	80,848	59,146	-21,702	-26.84%
12	58,803	45,138	-13,665	-23.24%
13	115,866	103,465	-12,401	-10.70%
14	28,306	12,137	-16,169	-57.12%
15	70,695	46,519	-24,176	-34.20%
16	79,950	60,069	-19,881	-24.87%
17	11,202	10,339	863	7.70%
Total	3,069,870	2,507,367	-562,503	-18.32%

Another standard statistical measure is the Percent Root Mean Square Error of the mean. This is simply the square root of the square of the difference between the observed and estimated volumes divided by the number of observations (links with observed counts), with the entire expression divided by the average volume for the highway links. Mathematically it is:

RMS = ([Observed volume less estimated volume]^{2} / number of links)$^{0.5}$

And the percent RMS is:

Percent RMS = (RMS / Average volume) * 100.0

This statistical measure was performed on all highway links that had an observed traffic count and was stratified by ranges of observed traffic volumes. This stratification is typical since it is normal that highway links with fewer vehicles will have a higher percent RMS.

The percent RMS ranged from 70 percent, for links that had an observed count of less than 10,000 vehicles per day, to 14 percent, for links that had an observed count between 60,000 and 70,000 vehicles per day. The percent RMS for all highway links was 40 percent. The percent RMS for the region is shown on Table 4. This percent RMS (ranging from 65 to 15 percent, is typical for a large urban travel demand model. Table 5 presents the percent RMS for the cities of Atlanta, Denver, and Orange County, California. Their percent RMS for low volume highways range from 87 percent, for Atlanta, to 43 percent, for Orange County for links between 5,000 and 10,000. Their percent RMS for high volume highways range from 14 percent, for Denver, to 19 percent, for Orange County for volumes over 60,000. The OMPO range of 65 percent to 19 percent (for volumes over 80,000) is therefore well within the range of these three urban areas.

Table 4
Root Mean Square Error Tables for the OMPO Region
Using All Counts Available

Volume Range	Average Volume Estimated	Average Volume Observed	Number of Links	Mean Square Error
0 to 9,999	5,015	6,070	176	69.3%
10,000 to 19,999	11,739	14,445	161	40.5%
20,000 to 29,999	20,215	25,012	69	34.4%
30,000 to 39,999	25,481	33,724	45	41.3%
40,000 to 49,999	30,105	43,039	18	34.4%
50,000 to 59,999	44,535	55,586	10	33.9%
60,000 to 69,999	61,234	63,806	7	15.7%
70,000 to 79,999	78,413	75,641	5	14.3%
80,000 +	97,205	96,613	16	18.7%
Total	17,115	20,392	507	40.4%

Table 5
Root Mean Square Error Tables For Other Urban Areas

Percent Root Mean Square Error for the 1995 Atlanta Region Screenline Links[2]

Volume Group	Average Volume	Number of Links	Percent Root Mean Square Error
0 to 5,000	2,797	95	93.1%
5,001 to 10,000	7,412	72	87.0%
10,001 to 20,000	14,717	119	62.6%
20,001 to 30,000	24,572	61	46.7%
30,001 to 40,000	34,094	45	46.3%
40,001 to 50,000	43,638	24	68.6%
50,001 to 60,000	52,256	13	21.3%
60,001 to 70,000	64,326	16	20.5%
70,001 to 90,000	87,263	24	17.6%
Greater than 90,000	113,805	10	17.1%
Total all links	24,158	479	50.2%

[2] "Transportation Solutions for the New Century", Appendices IV-V, "Model Documentation and Output", Atlanta Regional Commission, January 2000.

Percent Root Mean Square Error for the 1990 Denver Assignment[3]

Volume Group	Percent Root Mean Square Error
0 to 9,999	60%
10,000 to 29,999	28%
30,000 to 49,999	21%
50,000 to 79,999	12%
Greater than 80,000	14%

Percent Root Mean Square Error for the 1990 Orange County Assignment[4]

Volume Group	Percent Root Mean Square Error
0 to 4,999	115.8%
5,000 to 9,999	43.1%
10,000 to 19,999	28.3%
20,000 to 39,999	25.4%
40,000 to 59,999	30.3%
Greater than 60,000	19.2%

These three tests, VMT comparison, screenline and percent RMS, show that the OMPO travel demand models are estimating vehicle travel in a reasonable and accurate manner.

2 Transit Assignment Validation

The transit assignment procedure is an all-or-nothing assignment. But the trips are assigned to transit routes according to the headway of the bus routes, if more than one route can be "efficiently" used. Also the transit sub-modes of walk to local, walk to premium, park and ride, and kiss and ride trips are assigned using transit paths associated with the transit sub-mode. The morning and evening peak period transit trips are assigned to the peak transit network and the off-peak transit trips are assigned to the off-peak transit network. The two assignments are then combined to produce a daily transit assignment.

The transit assignment produces a report of the number of boardings for each transit route. A person's trip can include several boardings, if the person needs to transfer from one bus route to another. The person's trips from origin to destination is termed a "linked trip" while that portion of the trip made on one bus route is termed an "unlinked trip". There can obviously be more unlinked trips than linked trips depending on the number of transfers.

[3] "Travel Models for Regional and Subarea Planning in the Denver Region", Denver Regional Council of Governments
[4] "Orange County Transportation Analysis Model OCTAM-III, Travel Demand Model Development Methodology Report", Prepared for the County of Orange, Prepared by Barton-Aschman Associates, Inc. November 1992.

The validation of the transit assignment was to compare the model's boardings by transit route versus transit boarding data from the 1991 On-Board survey. The 1991 data was the nearest data available which contained the number of transit boardings by route. The observed and estimated boardings are shown on Table 6.

Table 6
Observed Boarding for 1991 and Estimated Boardings for the Base Year

Route Number	Daily Boardings: Observed	Estimated	Difference	Percent Difference	Route Number	Daily Boardings: Observed	Estimated	Difference	Percent Difference
Local Routes					Express Routes				
1	31,871	22,514	-9,357	-29.4%	80 & 82	1,761	570	-1,191	-67.6%
2 & 13	50,548	28,034	-22,514	-44.5%	81	1,218	146	-1,072	-88.0%
3	13,940	13,335	-605	-4.3%	83	954	863	-91	-9.5%
4	12,989	9,061	-3,928	-30.2%	84	1,256	285	-971	-77.3%
5	2,578	1,307	-1,271	-49.3%	85	1,167	262	-905	-77.5%
6	7,255	4,198	-3,057	-42.1%	86	143	85	-58	-40.6%
7	4,275	2,256	-2,019	-47.2%	87	152	39	-113	-74.3%
8	10,540	3,716	-6,824	-64.7%	88	363	179	-184	-50.7%
9	6,007	5,010	-997	-16.6%	89	153	30	-123	-80.4%
10	865	679	-186	-21.5%	90	177	56	-121	-68.4%
11	1,917	1,394	-523	-27.3%	91	829	347	-482	-58.1%
12	6,570	3,600	-2,970	-45.2%	92	230	157	-73	-31.7%
14	2,295	1,700	-595	-25.9%	93	969	427	-542	-55.9%
15	536	725	189	35.3%	94	25	31	6	24.0%
16	77	352	275	357.1%	95	130	32	-98	-75.4%
17	1,551	460	-1,091	-70.3%	96	126	128	2	1.6%
18	789	658	-131	-16.6%	97	204	100	-104	-51.0%
19	6,730	5,016	-1,714	-25.5%	98	0	209	209	N/A
20	6,026	2,756	-3,270	-54.3%	101	0	165	165	N/A
21	99	261	162	163.6%	102	0	100	100	N/A
22	554	446	-108	-19.5%	103	0	17	17	N/A
31 & 32	1,948	3,665	1,717	88.1%	104	0	5	5	N/A
47 to 50	7,447	19,785	12,338	165.7%	201	0	12	12	N/A
51	9,550	9,893	343	3.6%	202	0	20	20	N/A
52 & 62	9,276	17,723	8,447	91.1%	203	0	2	2	N/A
53	3,690	4,098	408	11.1%		9,857	4,267	-5,590	-56.7%
54	4,493	5,479	986	21.9%	Grand				
55 & 65	8,561	11,167	2,606	30.4%	Total	239,683	208,501	-31,182	-13.0%
56	4,610	4,844	234	5.1%					
57	5,687	7,678	1,991	35.0%					
58	2,402	4,303	1,901	79.1%					
70	451	1,952	1,501	332.8%					
71	137	939	802	585.4%					
72	852	2,099	1,247	146.4%					
73	826	417	-409	-49.5%					
74	40	603	563	1407.5%					
75	899	1,173	274	30.5%					
76	639	731	92	14.4%					
77	306	207	-99	-32.4%					
Total	229,826	204,234	-25,592	-11.1%					

The total estimated boardings are 13 percent lower than the observed boardings. However annual ridership estimates from DTS indicate about a seven percent growth between 1991 and 1995, so the difference is estimated at about 20 percent. Estimated boardings for local routes are about 11 percent lower than observed for 1991.

Given the observed and estimated boardings by route, the travel demand models appear to be estimating transit travel adequately, if somewhat low. Comparison to Year 2000 boardings (using year 2000 model estimates) is very favorable.

F. Sensitivity Testing of the Travel Models

Sensitivity Testing of the Travel Models

After the models have been calibrated and validated against observed 1995 data, a further set of model runs were conducted to demonstrate the sensitivity of the model to changes in socioeconomic and network inputs. A total of six additional model runs were conducted, as follows:

2000-1:	Existing year 2000 network and socio-economic data.
2000-2:	Existing year 2000 network, with additional capacity on Kapiolani Blvd and existing socioeconomic data.
2000-3:	Existing year 2000 network, with reduced capacity on Kapiolani Blvd and existing socioeconomic data.
2000-4:	Existing year 2000 network and socioeconomic data, but with a 50% increase in parking costs.
2025-1:	Base year 2025 socioeconomic forecast with no-build network.
2025-2:	Base year 2025 socioeconomic forecast with improved transit and Sand Island Tunnel.

1 2000-1: Year 2000 Base Scenario vs. Year 2000 Observed

The 2000-1 scenario was run as a basis for comparison with other year 2000 model runs. In addition, the results were compared to some available screenline and transit boarding data. Table 1 shows the Year 2000 daily volume comparison with screenlines. When compared to the same set of screenlines for 1995, the Year 2000 screenline exhibits a smaller error (Year 1995 total estimated screenline volumes were 19.8% below observed, versus 16.8% for Year 2000). Table 2 shows the Year 2000 am peak period (2-hour) volume comparison. The AM peak hour comparison is very favorable, with a total volume deviation of only -0.2%, slightly better than the +0.3% for 1995.

Finally, Table 3 shows the observed and estimated results for transit boardings. Overall, the observed and estimated boardings are less than 1% different.

Table 1
Comparison of Year 2000 Daily Counts versus Assigned Volumes for Seventeen Screenlines

Screen Line	Description	Count	Assigned Volume	Difference	Percent Difference
1	Nuuanu Stream Bridge	449,306	356,468	-92,838	-20.7%
2	Manoa-Palolo/Ala Wai Canal	314,177	258,727	-55,450	-17.6%
3	East of Ward Avenue	415,957	334,420	-81,537	-19.6%
4	Kapalama Drainage Canal	404,171	339,287	-64,884	-16.1%
5	Kalauao	201,333	169,616	-31,717	-15.8%
6	Waikele	167,622	152,134	-15,488	9.2%
7	Kahe Point	43,256	38,186	-5,070	-11.7%
8	Ewa	137,358	115,450	-21,908	-15.9%
9	Trans Koolau	115,376	92,281	-23,095	-20.0%
10	Waipo	172,695	149,128	-23,567	-13.6%
11	Miliani	88,313	86,959	-1,354	-1.5%
12	Haleiwa	21,181	22,295	1,114	5.3%
13	Waimea	13,250	9,304	-3,946	-29.8%
14	Hauula	12,126	12,047	-79	-0.7%
15	Kahaluu	18,655	18,176	-479	-2.6%
16	Kamehameha Hwy	32,804	12,773	-20,031	-61.1%
17	Maunawili	49,593	48,069	-1,524	-3.1%
18	Sandys Beach Park	10,629	3,092	-7,537	-70.9%
19	Kalanianole Hwy	32,072	25,110	-6,962	-21.7%
20	Olomana	23,472	12,007	-11,465	-48.8%
Total		2,723,346	2,264,529	-458,817	-16.8%

Table 2
Comparison of Year 2000 2-Hour AM Peak Counts versus Assigned Volumes for Seventeen Screenlines

Screen Line	Description	Count	Assigned Volume	Difference	Percent Difference
1	Nuuanu Stream Bridge	83,028	65,289	-17,739	-21.4%
2	Manoa-Palolo/Ala Wai Canal	39,274	43,864	4,590	11.7%
3	East of Ward Avenue	66,570	57,566	-9,004	-13.5%
4	Kapalama Drainage Canal	56,753	59,491	2,738	4.8%
5	Kalauao	36,334	36,751	417	1.1%
6	Waikele	24,761	27,608	2,847	11.5%
7	Kahe Point	5,743	7,630	1,887	32.9%
8	Ewa	20,490	22,150	1,660	8.1%
9	Trans Koolau	19,540	17,145	-2,395	-12.3%
10	Waipo	21,676	25,900	4,224	19.5%
11	Miliani	12,140	18,664	6,524	53.7%
12	Haleiwa	2,664	4,344	1,114	41.8%
13	Waimea	1,364	1,796	432	31.7%
14	Hauula	1,341	2,214	873	65.1%
15	Kahaluu	2,373	3,276	903	38.1%
16	Kamehameha Hwy	4,300	2,643	-1,657	-38.5%
17	Maunawili	7,053	9,176	2,123	30.1%
18	Sandys Beach Park	1,456	888	-568	39.0%
19	Kalanianole Hwy	4,164	4,662	498	12.0%
20	Olomana	2,963	2,276	-687	-23.2%
Total		413,987	413,333	-654	-0.2%

Table 3: Observed Boardings for 2000 and Estimated Boardings for Year 2000

	Daily Boardings					Daily Boardings			
Route Number	Nov 2000 Observed	Estimated	Difference	Percent Difference	Route Number	Nov 2000 Observed	Estimated	Difference	Percent Difference
Total	224,319	222,288	-2,031	-0.9%					
Local Routes	212,485	215,570	3,085	1.5%	Express Routes	11,834	6,718	-5,116	-43.2%
1	24,407	26,033	1,626	6.7%	80 A&B	945	405	-540	-57.1%
2	20,212	17,194	-3,018	-14.9%	81	1,706	108	-1,598	-93.7%
3	13,003	14,338	1,335	10.3%	82	258	194	-64	-24.8%
4	10,204	9,827	-377	-3.7%	83	812	1,432	620	76.4%
5	1,068	1,112	44	4.1%	84	854	561	-293	-34.3%
6	5,694	7,223	1,529	26.9%	85	1,058	353	-705	-66.6%
7	3,578	2,394	-1,184	-33.1%	86	71	119	48	67.6%
8	10,398	3,426	-6,972	-67.1%	87	77	41	-36	-46.8%
9	4,690	4,357	-333	-7.1%	88	351	190	-161	-45.9%
10	571	514	-57	-10.0%	89	114	26	-88	-77.2%
11	1,538	1,326	-212	-13.8%	90	172	56	-116	-67.4%
12	6,755	3,724	-3,031	-44.9%	91	878	774	-104	-11.8%
13	15,936	11,283	-4,653	-29.2%	92	218	241	23	10.6%
14	1,229	1,991	762	62.0%	93	1,347	774	-573	-42.5%
15	758	848	90	11.9%	94	0	111	111	#N/A
16	35	495	460	1314.3%	95	80	48	-32	-40.0%
17	1,426	481	-945	-66.3%	96	189	131	-58	-30.7%
18	796	684	-112	-14.1%	97	476	240	-236	-49.6%
19	4,802	4,600	-202	-4.2%	98	214	353	139	65.0%
20	3,656	2,637	-1,019	-27.9%	101	389	239	-150	-38.6%
21	36	226	190	527.8%	102	291	224	-67	-23.0%
22	1,210	489	-721	-59.6%	103	234	56	-178	-76.1%
31	623	770	147	23.6%	104	0	2	2	#N/A
32	1,396	3,533	2,137	153.1%	201	537	11	-526	-98.0%
40 (51)	8,467	9,908	1,441	17.0%	202	313	26	-287	-91.7%
41	980	0	-980	-100.0%	203	250	3	-247	-98.8%
42 (49)	7,874	9,125	1,251	15.9%					
47	0	4,627	4,627	#N/A					
48	0	1,876	1,876	#N/A					
50	0	4,173	4,173	#N/A					
52	4,888	9,135	4,247	86.9%					
53	3,022	3,411	389	12.9%					
54	3,892	4,707	815	20.9%					
55	3,843	6,541	2,698	70.2%					
56	4,007	5,431	1,424	35.5%					
57-58	7,581	12,148	4,567	60.2%					
62	5,406	9,109	3,703	68.5%					
65	2,317	5,753	3,436	148.3%					
70	204	2,052	1,848	905.9%					
71	57	776	719	1261.4%					
72	639	2,281	1,642	257.0%					
73	213	518	305	143.2%					
74	53	669	616	1162.3%					
76	367	731	364	99.2%					
77	264	184	-80	-30.3%					
401-403 (75)	924	1,450	526	56.9%					
411-412	180	0	-180	-100.0%					
413	72	0	-72	-100.0%					
421	273	0	-273	-100.0%					
431	474	0	-474	-100.0%					
432	1,367	0	-1,367	-100.0%					
433	1,494	0	-1,494	-100.0%					
A	11,169	779	-10,390	-93.0%					
B	5,244	304	-4,940	-94.2%					
C	3,193	366	-2,827	-88.5%					
F	0	11	11	#N/A					

2 Sensitivity to Baseline Growth

The baseline scenarios from 1995, 2000 (2000-1) and 2025 (2025-1) were compared to evaluate the sensitivity to regional, baseline growth. Table 4 describes the quantitative results. The growth in trips and vehicle-miles is in line with socioeconomic growth, especially households, since about 80% of the trip generation is controlled by productions related to households.

Table 4: Sensitivity to Baseline Growth in the OMPO Modeled Area

	Households[1]	Employment[2]	Daily Trips[1]	Daily Vehicle-Miles[3]
Year 1995	237,734	505,763	2,461,821	11,173,730
Year 2000 – Baseline	294,764	485,492	2,816,727	12,216,973
Change:2000-1995	57,031	-20,271	354,906	1,043,243
Percent Change: 2000-1995	24.0%	-4.0%	14.4%	9.3%
Year 2025 – Baseline	370,412	637,477	3,558,496	15,811,872
Change: 2025-1995	132,678	131,714	1,096,675	4,638,142
Percent Change: 2025-1995	55.8%	26.0%	44.5%	41.5%

[1]From Trip Generation report
[2]From Socioeconomic file zdxxxxxx.<alt>
[3]From "HEVAL" program output

3 Sensitivity to Changes in Roadway Capacity

Three year 2000 scenarios were modeled to test the effect of changes in capacity on links. Specifically, Kapiolani Blvd was changed from the baseline scenario to reflect an additional peak period capacity by adding a lane (Scenario 2000-2) and to reflect a decrease in capacity to a 4-lane section (Scenario 2000-3). Figure 1 shows the change in AM peak period link volume evident for the increased capacity condition, while Figure 2 shows the change in AM peak period link volumes resulting from a decrease in capacity.

Figure 1 illustrates that, with an increased capacity (in this case primarily adding a lane in the EWA-bound direction), additional trips are attracted to that facility which in this case is Kapiolani Blvd. This additional volume is drawn from King Street and the H-1 freeway. The red bands and numbers in Figure 1 represent an increase in volume from the base (2000-1) to the added-capacity alternative (2000-2). The green bands and numbers represent a decrease in volume between the base (2000-1) and added capacity alterative (2000-2). The bandwidth is proportional to the magnitude of change.

Figure 2 illustrates the effect of decreasing capacity on Kapiolani Blvd. In this case, trips are diverted away from Kapiolai and to other parallel facilities, primarily Beretania St. The colors represent increases and decreases in volumes, as in Figure 1.

In both Figures 1 and 2, and in the network in general, the user will typically notice changes in volume away from the area of change to the network. This is a common occurrence when testing network changes, and is a result of the iterative multi-path assignment routine. At equilibrium, alternative paths between an origin and destination will usually have very similar travel times. Any change in the network, however small, may affect the final balance of trips between paths, especially if those paths are used by many trips, and exhibit largely parallel alignments.

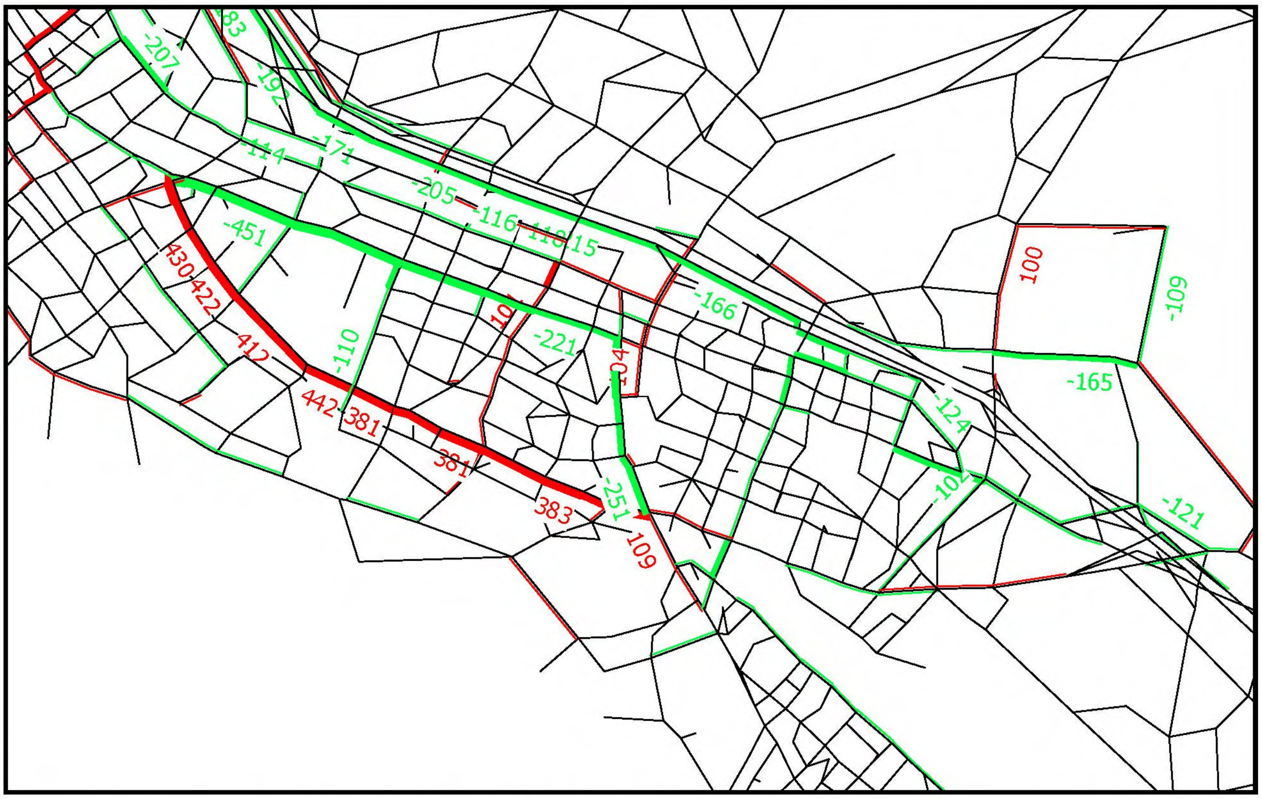


Figure 1: Change in AM 2-Hour Peak Assignment, 2000-2 less 2000-1

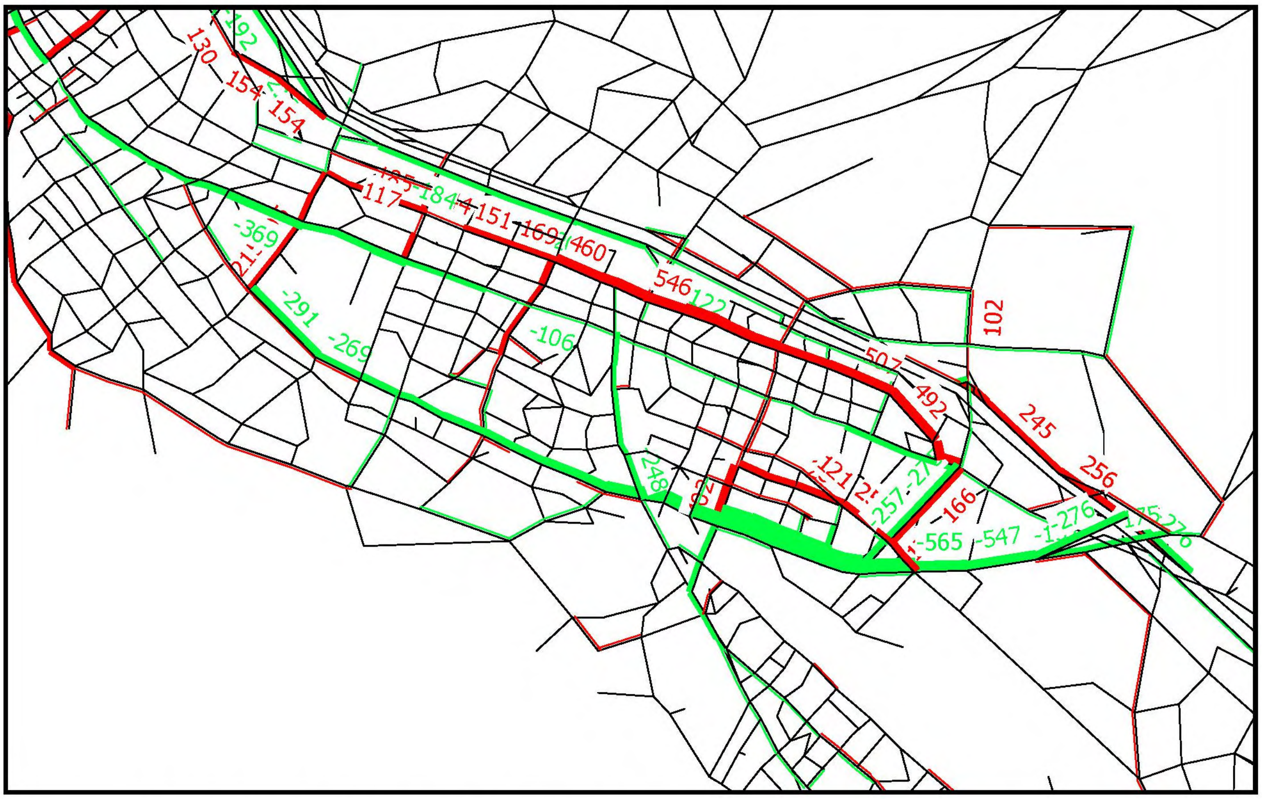


Figure 2: Change in AM 2-Hour Peak Assignment 2000-3 less 2000-1

4 Sensitivity to Changes in Parking Cost

The final Year 2000 comparison tested the effect of changes in parking costs. For this test, parking costs were raised 50% over those of the base year 2000 scenario. The effect of this change is to increase transit trips to the CBD by about 6,000 person-trips, changing the CBD-destined mode share from about 16% to 19%. In the AM 2-hour peak, vehicle trips into the CBD decreases by about 1,300 vehicle-trips, which is about 1.7% of the total AM 2-hour peak vehicle demand. In a separate calculation, the mode choice model's coefficient on cost was used to estimate the effect of a similar parking cost change for the CBD, and results were comparable.

5 Sensitivity to Changes in Transit Level of Service

The year 2025 scenarios were run to test the effect of an improved transit system. The 2025-2 scenario included an improved transit system, compared with the 2025-1 scenario. Table 5 summarizes regional travel statistics. Figure 3 shows the VMT by volume/capacity ratio for each alternative. All of these summary statistics indicate a reduction in vehicle trips and miles, and an increase in transit demand, as expected.

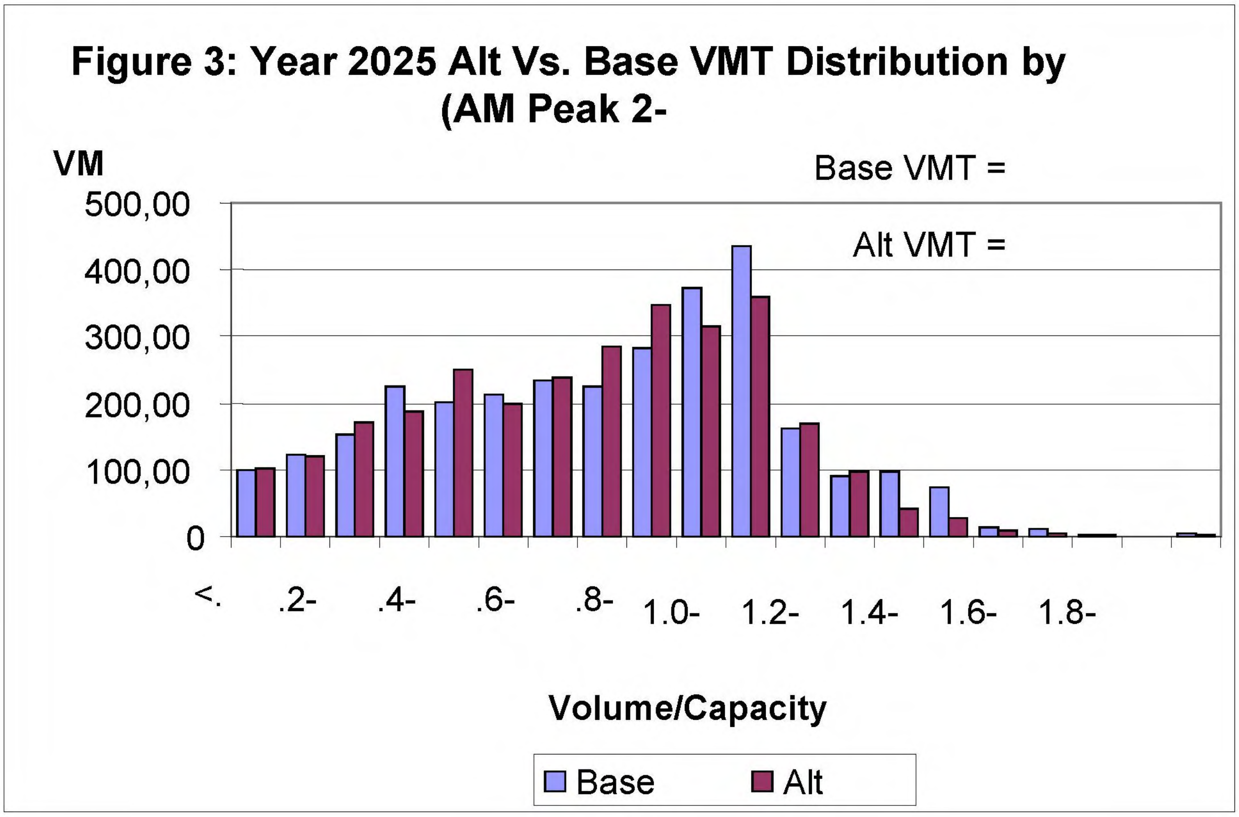


Table 5: Year 2025 OMPO Sensitivity Analysis Testing Improved Transit Service				
	Year 2025 Base	Year 2025 Alt	Change	Percent Change
Transit Trips	232,500	257,600	25,100	10.8%
Daily VMT	15,811,872	15,529,583	-282,289	-1.8%
Percent of VMT< 1.0 v/c	70.1%	75.5%	5.4%	-NA-

Appendix B: Model Review/Enhancement/ Re-Calibration Task Reports

1.0 Implementation and Testing of a Toll Choice Component for the Mode Choice Model

1.1 Introduction

This memorandum describes the theory, implementation and testing of a toll choice component for the OMPO regional mode choice model. The capability to test toll facilities was not included in the original model, and as there were and are no toll facilities on Oʻahu, there was no opportunity to gather data to support such a model. However, some options in the regional transportation plan included a toll facility, and future planning may include investigations into tolling options. Therefore, the capability of estimating toll demand was added to the mode choice model to facilitate current and future planning needs.

This memorandum will discuss the theoretical approach to toll modeling, the implementation of the toll estimation capability in the OMPO regional model, and a summary of the adjustment and sensitivity testing that was done, using a toll test case.

1.2 Model Theory

There are two competing approaches to modeling toll road demand within the context of a regional planning model. In one approach, toll facility use is considered a route choice, conducted after the traveler chooses a private auto, either as driver or passenger. In this approach, the "cost" of using a toll facility is included in a generalized cost assignment routine, and vehicles are routed on or off toll links according to the equilibrium assignment parameters. In the second approach, used in this application, use or non-use of a toll facility is considered a sub-mode choice to auto modes. Implementing this approach means modifying the mode choice model to allow for a new nest below drive-alone, 2 and 3+ person auto modes. One way in which to differentiate these approaches is by the basic assumption they make about the decision process of travelers who use toll facilities. A *tactical* decision during the trip, where the auto traveler decides to use a toll facility because of the immediate perceived traffic conditions would be best modeled by an assignment-based process. A strategic decision, made routinely by the auto traveler in anticipation of the perceived costs prior to the trip would be more in line with treatment as a mode, and therefore implemented in the mode choice model. In truth, there are probably elements of both of these behaviors present in the traveling public. We have selected the strategic model of toll choice behavior since it offers the advantage of a logit-based decision model, and can incorporate behavioral differences, such as value of time, evident in socio-economic and trip purposes.

Based on past experience, there are several variables that influence toll use. We have used the following in our OMPO model implantation:

1. <u>Toll cost:</u> The monetary cost (in cents) of using a "toll-preferred" path.
2. <u>Distance on Toll Facility:</u> The distance (in miles) of toll lanes used along the "toll-preferred" path. This variable allows a greater benefit for longer toll-facility trips, which presumably saves more time. It also discourages paths that might jump on and off toll barrier-free toll facilities for short distances.

3. Time Savings: The time (in minutes) that is saved by the "toll-preferred" path over the non-toll path. Toll facilities are built to provide a time savings over parallel congested paths, so this time savings from toll lane use is an important variable.
4. Additional Distance: With the same weight as the toll distance, this variable is the additional distance (if any) used by the toll-preferred path over the non-toll path, and discourages unreasonable toll paths. This also serves to counterbalance the toll lane distance variable, so that only the net distance saved/expended becomes important.

1.3 Implementation

There are two primary aspects to the toll choice implantation. First, the proper level of service variables, such as toll time, distance and cost, must be generated from the highway network, along with the standard variables. Secondly, the mode choice model itself must be modified to accept these new toll variables, and implement them in a new toll/non-toll nest.

1.3.1 Toll LOS Variable Generation

The analysis of toll facilities using the OMPO regional travel demand model requires some revisions to the highway network link attributes, the highway path building procedures and highway network building/unbuilding steps. The resulting level of service matrices now includes both toll and non-toll paths, as well as toll distance and toll cost for the toll paths. Non-toll paths exclude all toll links, while toll paths include all allowable toll links for a given vehicle assignment class. No a priori weighting is done to favor toll facilities.

In order to accommodate tolls on regular toll facilities, as well as other occupancy-stratified tolls such as may be used on HOT lanes; three additional link attributes have been added. These link attributes are:

toll1: toll, in cents assessed all drive-alone vehicles crossing a link

toll2: toll, in cents assessed all 2-person occupancy vehicles crossing a link

toll3: toll, in cents, assessed all 3+ person occupancy vehicles crossing a link

For regular toll facilities, toll1, toll2 and toll3 will be identical. However, this structure does allow for differential tolls by occupancy, that might apply for HOT (High-occupancy toll) lane facilities.

Though transparent to the user, three additional link attributes are also created within the highway skim procedure. These are tdist1, tdist2, and tdist3, and are used to sum toll lane distance for drive-alone, 2-person and 3+ person occupancy autos.

The other coding change that the user must include is to specify the type of facility. This is done through the use of the limita, limitm and limitp link attributes. (the "a" "m" and "p" refer to am peak, midday or off-peak and pm peak, respectively). In addition to the standard values, three additional values have been added – 10, 11 and 12.

Limita, limitm and limitp values:

1 – open to all vehicles

2 – Single occupancy vehicles and trucks are prohibited (i.e., HOV 2+ lanes)

3 – Single occupancy vehicles, 2-person autos and trucks are prohibited (i.e., HOV 3+ lanes)

4 – Bus and transit only links

5 – bus/transit/bike and walk links

6 – trucks prohibited

7 – walk and bike only links

8 – usually used to show roadway links needed for transit but not highway (transit support links)

9 – undefined

10 – traditional toll, all vehicles tolled, including HOT lanes where all vehicles have some toll

11 – HOT lane where Drive-Alone vehicles pay, and 2 and 3+ person autos are free

12 – HOT lane where Drive-Alone and 2-person autos pay, and 3+ person autos are free

Therefore, by careful combinations of the limita, limitm and limitp values, and specification of toll1, toll2 and toll3, the user can specify almost any combination of regular and HOT lane tolls. The use of toll-lane distance offers somewhat less flexibility, since only a fixed, per-mile toll rate may be applied by auto occupancy category.

Revised Highway skims:

The revised level of service matrices that are produced are expanded from two to six tables for each skim type. The following tables are now produced by the highway skim procedures, as shown in Table 1. Tables 1 and 2 remain the same.

Table 1: OMPO Regional Model Highway Skims (with toll paths)

Table	Description
1	Time, Non-toll path (minutes)
2	Distance, Non-toll path (miles)
3	Time, Toll path (minutes)
4	Distance, Toll path (miles)
5	Distance on toll facilities, along toll path (miles)
6	Toll on toll path (cents), derived from toll1, toll2 and toll3 link attributes

The number of highway level of service files, and their names, remain the same. These files are:

skpkxx01.<alt> - peak drive-alone

skpkxx02.<alt> - peak 2-person autos

skpkxx03.<alt> - peak 3+ person autos

skopxx01.<alt> - offpeak drive-alone

skopxx02.<alt> - offpeak 2-person autos

skopxx03.<alt> - offpeak 3+ person autos

The change to the network and highway skim files also includes changes to the following control files:

Hwybld/data/ubldlink.set

Hwy/atrhwy.set

Hwy/skttxxau.set

Fdb/atrhwy.set

Fdb/atrhwyop.set

Fdb/skttxxau.set

In addition, the "makeclas" and "feedback" programs will need to be revised to accommodate the toll1, toll2 and toll3 attributes.

Note that the toll skim tables are always produced, but will be populated with 0 if no toll facilities are designated in the network.

1.3.2 Mode Choice Model Changes

The mode choice model was modified to calculate toll utilities for drive-alone, 2-person and 3+ person auto modes. These utilities were identical to those of the corresponding non-toll equations, with the following terms added:

C_{tsav}*Toll Time Savings +

C_{tdst}*Toll Road Distance +

C_{tout}*Toll Path Excess Distance +

C_{toll}*Toll Cost

In addition, the toll/non-toll nest level has a logsum coefficient.

A logical parameter in the control file (tollmdl) is used to direct the model on whether or not to use the toll nest.

Finally, a new output table is produced which includes toll and non-toll auto trips. The tables are:

1. drive alone non-toll trips
2. drive alone toll trips
3. 2-person non-toll trips
4. 2-person toll trips
5. 3-person non-toll trips
6. 3-person toll trips

1.4 Adjustment

Since there is no available observed data for toll behavior, a strict calibration of the parameters is not possible. The values of C_{tsav}, C_{tdst}, C_{tout} and C_{toll}, as well as the toll nest logsum coefficient are borrowed from the toll model used in Houston by the Houston-Galveston Council of Governments (HGAC). However, the C_{toll} value should be related to the implied value of time, which varies by trip purpose. Consequently, a sensitivity analysis was conducted using the hypothetical tolled tunnel in Pearl Harbor, to examine the response of the mode choice model to changes in the value of the toll cost coefficient, C_{toll}. Figure 1 shows the toll demand as a function of the cost coefficient. The graph in Figure 1 shows that for reasonable values of time (VOT) of $10/hr to $20/hr there is little variation in demand. A toll VOT of $15 was used in the HGAC model, so this value is used for the OMPO model.

Since the VOT varies somewhat by trip purpose, the C_{toll} value will also change. The final coefficient values are:

C_{tsav} = +0.271

C_{toll} = -0.00074 (purposes wh,ww,wo,wn & nc – JTW & College)

C_{toll} = -0.00072 (purposes ns,no,nn,aw,an – non-work related & JAW)

C_{toll} = -0.00044 (purposes nk – HBK-12)

C_{tout} = -0.070

C_{tdst} = +0.070

C_{lstoll} = 0.50 (toll nest logsum coefficients)

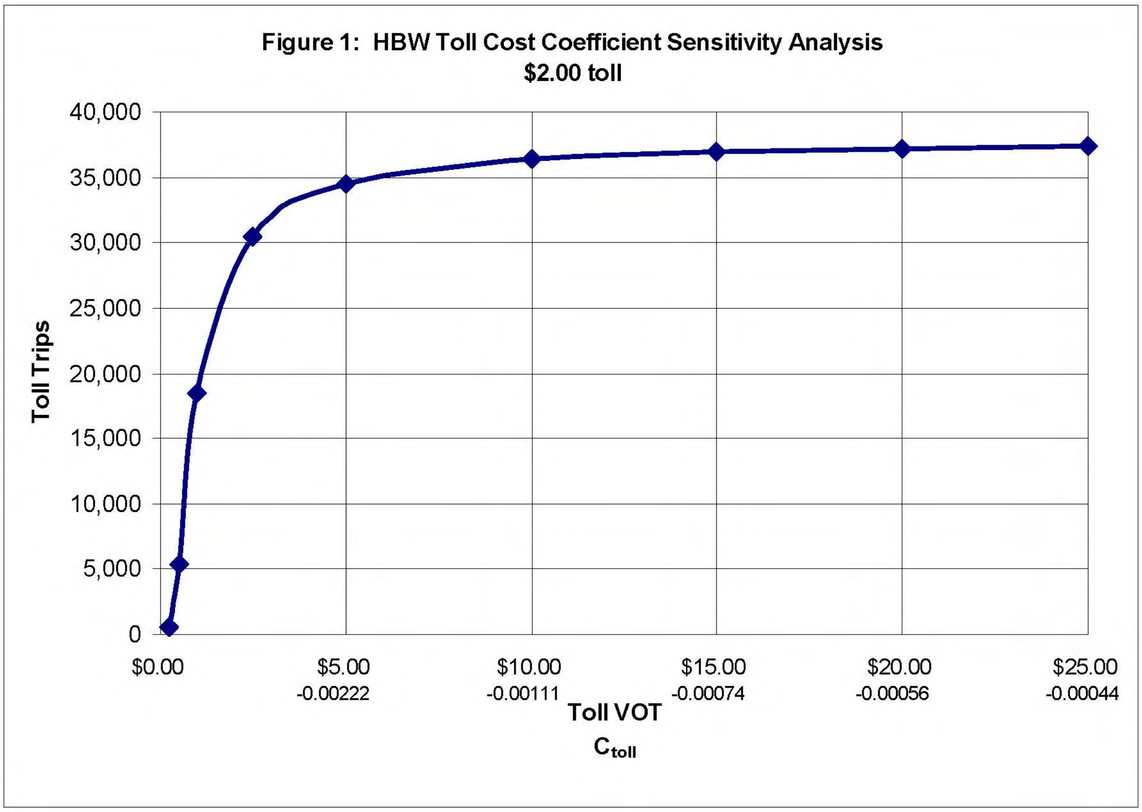


Figure 1: HBW Toll Cost Coefficient Sensitivity Analysis
$2.00 toll
Toll Trips
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
$0.00
$5.00
-0.00222
$10.00
-0.00111
$15.00
-0.00074
$20.00
-0.00056
$25.00
-0.00044
Toll VOT
C toll

2.0 On-Board Survey Assignment

Since the OMPO Travel Demand Model was revised and updated several times in the last several years along with the TAZ system being expanded from 284 to 762 zones, the 1992 On-Board Survey was assigned using the latest model updates, and the new 762 zone system.

The survey trip tables were first converted from the 284 to the 762 system. This was done using a lookup table between the 284 and 762 zone system. For example, if a 284 system TAZ was split into 4 - 762 system zones, the trips were uniformly split into quarters (25%).

The OMPO model has 4 transit sub-modes; walk to local, walk to premium, park and ride, and kiss and ride, and two time periods; peak and off peak. Thus 8 trip tables were constructed for the 4 sub-modes and 2 time periods and these tables were assigned to their respective networks. The assignments were then combined to produce a daily transit assignment.

The transit trip tables were assigned using the same path-building procedure used for skimming (Table 1). Table 2 shows the transit speed factors used for each time period. The resulting transit boardings by class of service are shown in Table 3. Table 4 shows the resulting transit boardings by route. Tables 3 and 4 clearly show that we are underestimating trips on express routes and overestimating trips on certain suburban trunk and feeder routes.

A closer look at express route trips revealed that although the on-board survey shows 9857 boardings on express routes, only 4853 were assigned on express routes. The 1992 On Board Survey did not have accurate geocoded data. The only information available was production and attraction zone at the 284 zone system level. The conversion of the trip tables from the 284 zone system to the 762 zone system resulted in some trips not being assigned to express routes as the zones to which they were allocated may not have appropriate access to the express route line. To check this assumption, the trip tables were assigned to a 284 zone network, and of the 9857 boardings on express routes, 9487 trips (96%) were assigned on express routes.

Some local routes also had over- and under-estimated boardings compared to the on-board survey. When the assignment was run on the 284 zone system, the percent difference between the observed and estimated was less severe. For example, Route 8 had 6586 boardings (37% difference) in the 284 zone system assignment compared to 5079 (52% difference) in the 762 zone system assignment. Route 20 had 6919 boardings (15% difference) in 284 system assignment compared to 2865 (52%) in the 762 zone system assignment. And Route 50 had 10652 boardings (43%) in the 287 zone system assignment compared to 15876 (113%) in the 762 zone system assignment.

The assignments from the 284 zone system more accurately reflect some of the results found in the 1992 on-board survey. The lookup table to convert the trip tables from 284 zones to 762 zones sometimes did not accurately reflect where trips were coming from and going to. We did not have geocoded coordinates so we could not directly create trips tables in the 762 zone system.

Despite some of these over-estimated and under-estimated routes, a 95% R2 in Figure 1 shows that the goodness of fit is excellent and that the transfer penalty and other path parameters seem appropriate to reflect observed behavior.

Table 1. Current Model Path Building Parameters

Walk to Local Bus	
Walk Speed	3 MPH
Maximum Walk Distance	5 miles
Maximum Initial Wait Time	15 minutes
Initial wait time factor	2
In-vehicle time factor	1
Transfer Wait Time factor	2
Transfer Wait Time penalty	6 minutes
Maximum Perceived path time	300 minutes
Walk to Express Bus	
Walk Speed	3 MPH
Maximum Walk Distance	5 miles
Maximum Initial Wait Time	15 minutes
Initial wait time weight factor	2
Bonus wait time weight for express	1.4 minutes
In-vehicle time factor	1
Bonus in-vehicle time weight for express	0.7
Transfer Wait Time factor	2
Transfer Wait Time penalty	6 minutes
Maximum Perceived path time	300 minutes
Drive Access/Egress to Bus	
Walk Speed	3 MPH
Maximum Drive Time	15 minutes
Maximum Walk Distance	5 miles
Maximum Initial Wait Time	15 minutes
Initial wait time factor	2
In-vehicle time factor	1
Transfer Wait Time factor	2
Transfer Wait Time penalty	6 minutes
Maximum Perceived path time	300 minutes

**Note: The kiss and ride parameters were the same as the walk to local bus mode.

Table 2. Bus Speed Factors

Functional Class	Peak Factor	Off Peak Factor
Freeways / Expressways	1.0	1.0
Ramps	1.0	1.0
Arterial I	1.54	1.65
Arterial II	1.24	1.53
Arterial III	1.95	0.83
Collector I	1.22	1.50
Collector II	1.81	1.18
Local	0.83	1.41

Table 3. Transit Boardings by Class of Service

Class of Service	1991 Observed	1995-1996 Base Year (OBS Assn)	Percent difference
Urban Trunk	145,221	135,590	0.93
Urban Collector	20,874	18,850	0.90
Suburban Trunk	59,581	83,086	1.39
Suburban Feeder	4150	6775	1.63
Express	9,857	4,853	0.49
Total	***239,683***	***249,154***	***1.04***

Table 4. Transit Boardings by Class of Service and Route Number

Route No.	1991 Observed	1995-1996 Base Year (OBS Assn)	percent difference
Urban Trunk			
1	31,871	34539	*1.08*
2&13	50,548	49208	*0.97*
3	13,940	14828	*1.06*
4	12,989	13232	*1.02*
8	10,540	5079	*0.48*
9	6,007	5723	*0.95*
12	6,570	4937	*0.75*
19	6,730	5179	*0.77*
20	6,026	2865	*0.48*
Subtotal	*145,221*	*135,590*	*0.93*
Urban Collector			
5	2,578	1500	*0.58*
6	7,255	5511	*0.76*
7	4,275	4688	*1.10*

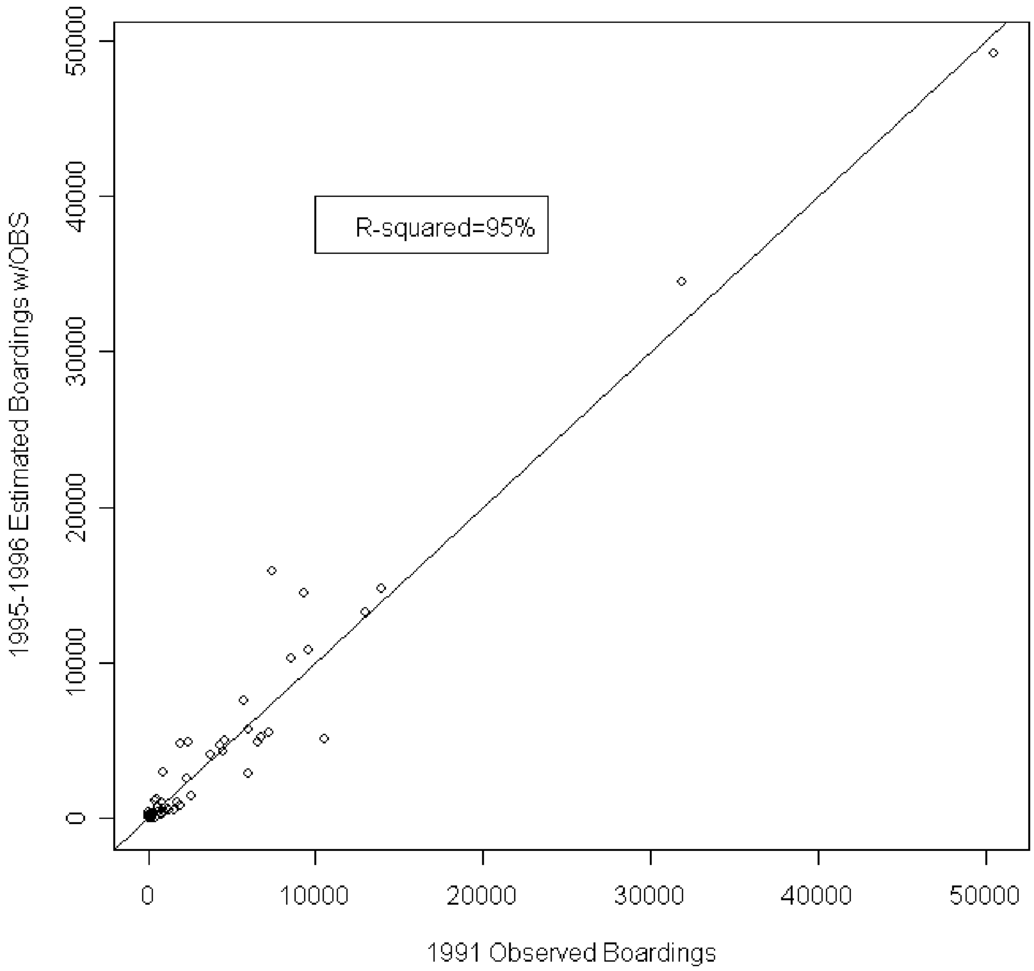
Table 4. Transit Boardings by Class of Service and Route Number

Route No.	1991 Observed	1995-1996 Base Year (OBS Assn)	percent difference
10	865	683	*0.79*
14	2,295	2626	*1.14*
15	536	1291	*2.41*
16	77	224	*2.91*
17	1,551	576	*0.37*
18	789	1057	*1.34*
21	99	209	*2.11*
22	554	485	*0.88*
Subtotal	*20,874*	*18,850*	*0.90*
Suburban Trunks			
11	1,917	892	*0.47*
31&32	1,948	4816	*2.47*
47 to 50	7,447	15876	*2.13*
51	9,550	10828	*1.13*
52/62	9,276	14456	*1.56*
53	3,690	4120	*1.12*
54	4,493	4278	*0.95*
55/65	8,561	10305	*1.20*
56	4,610	5037	*1.09*
57	5,687	7526	*1.32*
58	2,402	4952	*2.06*
Subtotal	*59,581*	*83,086*	*1.39*
Suburban Feeder			
70	451	1142	*2.53*
71	137	361	*2.64*
72	852	623	*0.73*
73	826	263	*0.32*
74	40	397	*9.93*
75	899	2980	*3.31*
76	639	711	*1.11*
77	306	298	*0.97*
Subtotal	*4,150*	*6,775*	*1.63*
Express			
80/82	1,761	1047	*0.59*
81	1,218	587	*0.48*
83	954	416	*0.44*
84	1,256	520	*0.41*
85	1,167	676	*0.58*

Table 4. Transit Boardings by Class of Service and Route Number

Route No.	1991 Observed	1995-1996 Base Year (OBS Assn)	percent difference
86	143	0	*0.00*
87	152	48	*0.32*
88	363	77	*0.21*
89	153	63	*0.41*
90	177	57	*0.32*
91	829	368	*0.44*
92	230	24	*0.10*
93	969	457	*0.47*
94	25	13	*0.52*
95	130	31	*0.24*
96	126	81	*0.64*
97	204	130	*0.64*
98		38	
101		75	
102		61	
103		0	
104		1	
201		30	
202		53	
203		0	
Subtotal	*9,857*	*4,853*	*0.49*
Grand Total	***239,683***	***249,154***	***1.04***

Figure 1. 1991 Observed Boardings and 1995-96 Estimated Boardings with On Board Survey Data for each Route



3.0 Tests of Alternative Highway Volume–Delay Functions

3.1 Problem

Since the implementation of the Akçelik volume delay functions, the OMPO Travel Demand Model has produced highway speeds that are too fast for base year as well as future scenarios. The nature of the Akçelik curves has shown that delay does not become appreciable until volume to capacity (VC) ratio is greater than or equal to 1. So a facility could have a VC ratio of 0.9 with the highway operating at near free-flow conditions. In addition, because of the extreme sensitivity of the Akçelik curves around vc=1.0, congested speeds tend to be highly variable along corridors.

A more gradual volume-delay function would, we believe, produce more reasonable travel speeds and lead to more stable and predictable results in this aspect of the model. This memo documents a test of other volume delay functions used in other areas as well as the volume delay functions used in the past OMPO Travel Demand Models.

3.2 Current Volume Delay Functions used in OMPO Model

Akçelik volume delay functions are used in the current OMPO Travel Demand Model.

The volume delay functions were developed using a speed-flow relationship developed by Rupinder Singh, based on a speed-flow model originally developed by Akçelik. This speed-flow relationship is much more sensitive than the "classical" BPR curves. That is at volume capacity ratios (v/c) of more than 1.0, the Akçelik formulation will show much lower speeds (and higher times) than the standard formulation. There are five specifications, for various facility types, plus a general specification and a "do nothing" formulation for centroids.

The Akçelik speed-flow model has the mathematical formulation of:

t = to + {0.25T[(x-1) + {(x-1)2 + (8Jax/QT)} 0.5]}

where:

t = average travel time per unit distance (hours/mile)

to = free-flow travel time per unit distance (hours/mile)

T = flow period, i.e., the time interval in hours, during which an average arrival (demand) flow rate, v, persists

Q = Capacity

x = the degree of saturation i.e., v/Q

Ja = the delay parameter

For the Honolulu (OMPO) model there were different delay parameters by facility type. These delay (Ja) parameters were:

Freeways, Expressways, and High speed Ramps – 0.8

Arterial I – 1.6

Arterial II and III – 3.2

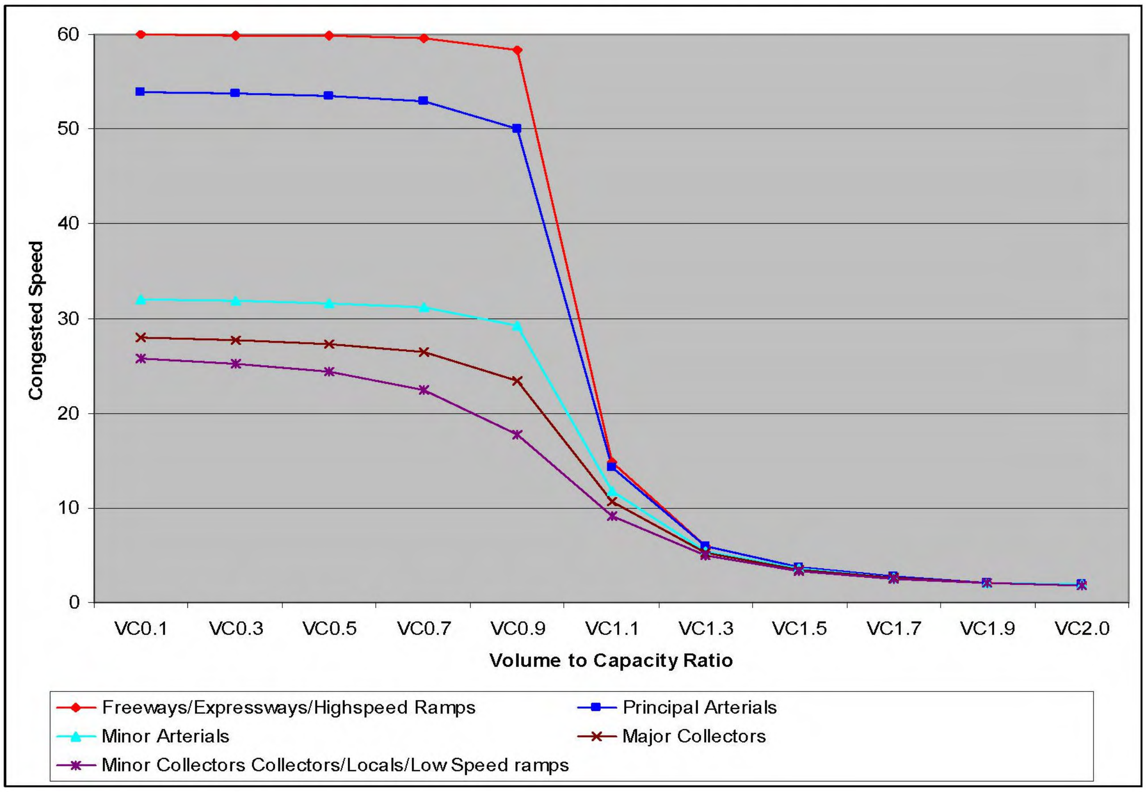
Collector I – 6.4

Collector II, Local Streets, and Low Speed Ramps – 12.8

Centroid Connectors – No adjustment made to these links

The following figure displays the degradation in speed by the delay factors by facility type and VC ratio.

Figure 1. Akçelik Curve Speed Degradation for the OMPO Model



We can clearly see from this graph that the speeds don't start to degrade until volume to capacity ratio (VC) reaches 1. And when the speed does start to degrade, it degrades dramatically.

3.3 Previous Volume Delay Functions used in OMPO Model

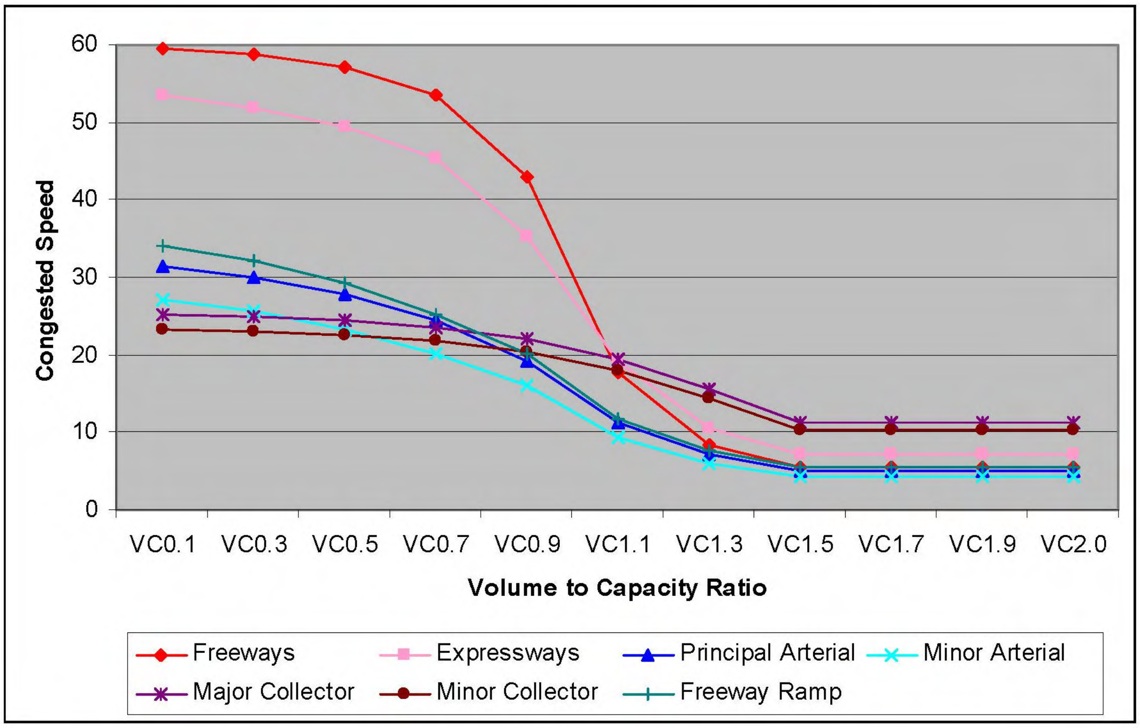
The functions used in 1995 in the OMPO Travel Demand Model were similar to BPR volume delay functions. The following table shows the delay factor used by facility type and VC ratio.

Table 1. VDFs used in 1995 OMPO Travel Demand Model

	Volume to Capacity Ratio							
functional class	**VC=0.1**	**VC=0.3**	**VC=0.5**	**VC=0.7**	**VC=0.9**	**VC=1.1**	**VC=1.3**	**VC=1.5**
Freeways	1.01	1.02	1.05	1.12	1.4	3.4	7.12	11.05
Expressways	1.01	1.04	1.09	1.19	1.53	2.83	5.09	7.59
Principal Arterial	1.02	1.07	1.15	1.31	1.67	2.84	4.42	6.22
Minor Arterial	1.03	1.09	1.2	1.39	1.74	3	4.58	6.35
Major Collector	1.03	1.04	1.06	1.1	1.18	1.34	1.66	2.3
Minor Collector	1.03	1.04	1.06	1.1	1.18	1.34	1.66	2.3
Freeway Ramp	1.03	1.09	1.2	1.39	1.74	3	4.58	6.35

Figure 2 below shows that the congested speeds degrade gradually as the volume to capacity ratio increases.

Figure 2. VDFs – 1995 OMPO Travel Demand Model Speed Degradation



3.4 Conical Volume Delay Functions

A new class of functions named conical volume-delay functions due to its geometrical interpretation as hyperbolic conical sections was developed by Heinz Spiess.

The conical congestion function is defined as:

$$T^C(x) = T_0 * (2 + \sqrt{\alpha^2(1-x)^2 + \beta^2} - \alpha(1-x) - \beta)$$

where:

β is given as $\beta = \dfrac{2\alpha - 1}{2\alpha - 2}$,

α is any number larger than 1,

Tc(x) = average travel time per unit distance (hours/mile),

To = free-flow travel time per unit distance (hours/mile),

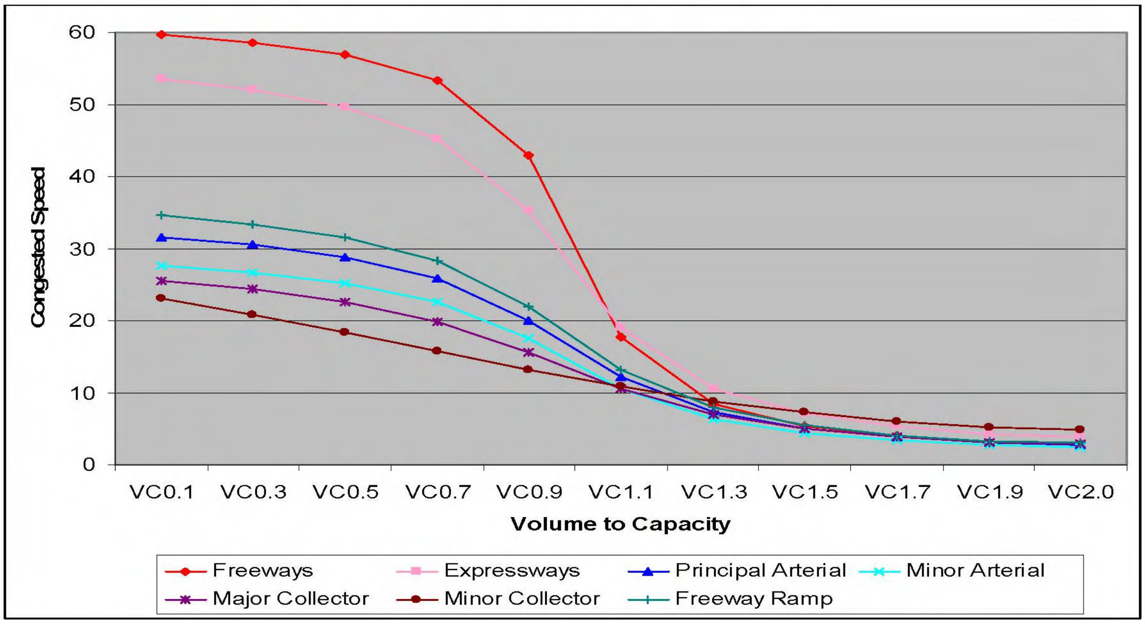
x = volume to capacity.

The alpha values used to specify these curves are:

Freeway:	10.0
Expressway:	6.6
Principal Arterial:	5.2
Minor Arterial:	5.2
Major Collector:	4
Minor Collector:	2
Ramps:	5.3

The alpha values are roughly equivalent to the exponent in the BPR function. As the exponent increases the slope of the curve at V/C=1 also increases. As with the BPR exponent, we would expect higher values for freeways and expressways vs. arterials and collectors. These values were chosen to more closely follow the previous look-up tables of the 1995 model.

Figure 3. Conical Volume Delay Functions Speed Degradation



The conical functions here provide an almost identical speed degradation pattern as the functions used in the 1995 OMPO Travel Demand Model.

3.5 Volume Delay Function Comparisons

As seen in Figure 1 above, the Akçelik curve formulation does not degrade speeds until volume to capacity ratios reach one. Thus vehicle hours traveled using the Akçelik functions (296,909) was significantly less than vehicle hours traveled using either the Conical functions (309,104) or the volume delay functions for the 1995 OMPO model (307,795). Table 2 thru 4 below compares the vehicle miles traveled and vehicle hours traveled by facility type for the 2000 base year Model run using the three different volume delay functions. As expected, the differences are more pronounced in the horizon year Transit alternative (Tables 5 thru 7).

Table 2. Akçelik VDF 2000 Base Year VMT & VHT

Facility Type	AM Peak VMT	Off Peak VMT	PM Peak VMT	Total VMT	AM Peak VHT	Off Peak VHT	PM Peak VHT	Total VHT
Freeways	1,353,584	2,029,928	1,449,958	4,833,470	31,652	31,062	28,229	90,943
Expressways	373,723	583,072	419,511	1,376,306	7,265	9,437	7,304	24,006
Class I Arterials	482,667	575,702	568,008	1,626,377	16,509	15,019	18,412	49,940
Class II Arterials	377,644	504,669	423,774	1,306,087	11,158	13,427	11,565	36,150
Class III Arterials	139,133	202,369	159,697	501,198	5,107	6,154	5,333	16,594
Class I Collectors	126,783	185,672	151,101	463,556	4,665	6,141	5,548	16,354
Class II Collectors	195,017	288,662	231,105	714,784	7,624	9,730	8,770	26,123
Local Streets	58,077	85,924	65,749	209,750	5,438	4,275	6,267	15,979
High Speed Ramps	72,921	120,415	77,811	271,147	1,935	2,303	2,731	6,968
Low Speed Ramps	28,392	64,922	36,196	129,510	3,375	4,613	5,863	13,851
Total	**3,207,939**	**4,641,335**	**3,582,910**	**11,432,184**	**94,728**	**102,159**	**100,022**	**296,909**

Table 3. 1995 OMPO Model VDFs' 2000 Base Year VMT & VHT

Facility Type	AM Peak VMT	Off Peak VMT	PM Peak VMT	Total VMT	AM Peak VHT	Off Peak VHT	PM Peak VHT	Total VHT
Freeways	1,326,646	2,013,819	1,417,377	4,757,841	34,654	32,530	29,801	96,986
Expressways	367,610	569,496	415,230	1,352,336	8,226	9,602	8,441	26,269
Class I Arterials	452,085	574,412	528,566	1,555,064	16,508	15,938	19,871	52,316
Class II Arterials	365,133	490,268	418,690	1,274,091	12,736	13,678	13,831	40,245
Class III Arterials	135,929	196,966	154,744	487,639	5,492	6,473	6,101	18,067
Class I Collectors	123,411	178,725	150,130	452,266	4,644	6,172	5,917	16,733
Class II Collectors	200,214	283,692	241,401	725,306	7,435	9,897	9,149	26,480
Local Streets	64,590	85,520	71,778	221,888	2,972	3,951	3,414	10,337
High Speed Ramps	70,766	115,301	73,974	260,042	2,192	2,550	2,345	7,088
Low Speed Ramps	29,692	62,114	41,274	133,080	3,085	4,496	5,693	13,274
Total	**3,136,075**	**4,570,313**	**3,513,164**	**11,219,553**	**97,945**	**105,287**	**104,563**	**307,795**

Table 4. Conical VDFs' 2000 Base Year VMT & VHT

Facility Type	AM Peak VMT	Off Peak VMT	PM Peak VMT	Total VMT	AM Peak VHT	Off Peak VHT	PM Peak VHT	Total VHT
Freeways	1,337,632	2,001,038	1,429,655	4,768,326	32,352	32,090	30,639	95,080
Expressways	366,328	564,819	409,862	1,341,008	8,146	9,471	8,103	25,720
Class I Arterials	452,883	586,849	540,516	1,580,248	16,037	16,017	20,015	52,068
Class II Arterials	361,942	499,288	416,056	1,277,287	11,768	13,699	12,968	38,435
Class III Arterials	135,949	199,752	158,875	494,576	5,150	6,336	5,933	17,418
Class I Collectors	115,535	174,623	139,103	429,261	4,824	6,242	5,885	16,951
Class II Collectors	197,084	294,035	242,089	733,208	8,169	10,133	9,838	28,139
Local Streets	59,706	84,855	68,188	212,748	5,859	4,318	5,924	16,101
High Speed Ramps	80,424	118,441	78,972	277,837	1,525	2,262	1,509	5,296
Low Speed Ramps	26,949	63,019	34,462	124,430	3,399	4,724	5,771	13,894
Total	**3,134,431**	**4,586,718**	**3,517,779**	**11,238,929**	**97,228**	**105,291**	**106,585**	**309,104**

Table 5. Akçelik VDF 2030 Transit Alternative VMT & VHT

Facility Type	AM Peak VMT	Off Peak VMT	PM Peak VMT	Total VMT	AM Peak VHT	Off Peak VHT	PM Peak VHT	Total VHT
Freeways	1,601,670	2,586,236	1,774,839	5,962,745	32,050	39,682	35,598	107,330
Expressways	444,241	724,261	507,371	1,675,873	9,047	11,964	9,766	30,777
Class I Arterials	549,281	766,267	672,543	1,988,091	16,481	19,019	21,557	57,057
Class II Arterials	458,394	639,352	538,531	1,636,277	15,483	16,982	17,505	49,970
Class III Arterials	173,040	242,340	211,466	626,846	5,362	7,360	6,645	19,367
Class I Collectors	154,411	224,570	193,431	572,412	5,160	7,356	7,033	19,549
Class II Collectors	221,929	323,330	267,031	812,290	8,422	11,222	10,418	30,062
Local Streets	67,361	94,879	75,520	237,760	5,404	4,377	4,632	14,412
High Speed Ramps	83,469	141,788	86,316	311,573	1,939	2,697	2,686	7,322
Low Speed Ramps	36,160	86,236	43,180	165,576	3,681	5,538	6,868	16,087
Total	**3,789,957**	**5,829,259**	**4,370,227**	**13,989,443**	**103,029**	**126,198**	**122,706**	**351,933**

Table 6. 1995 OMPO Model VDFs' 2030 Transit Alternative VMT & VHT

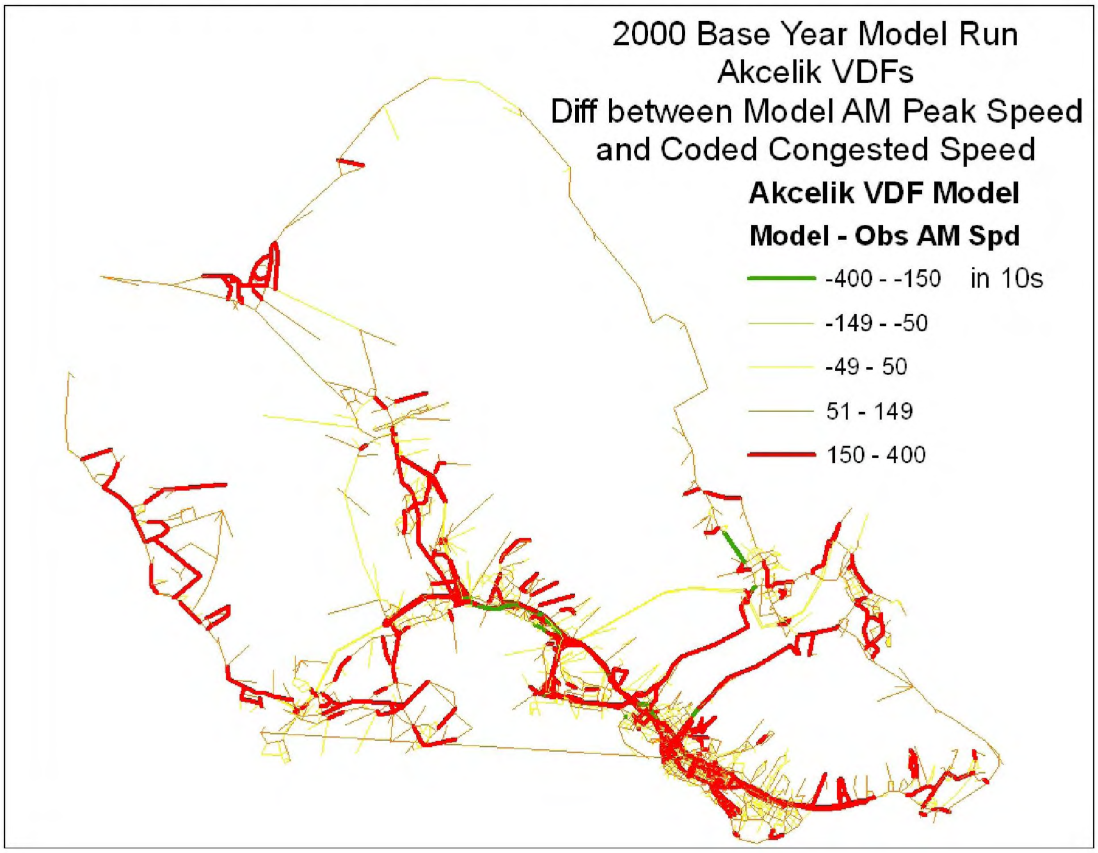
Facility Type	AM Peak VMT	Off Peak VMT	PM Peak VMT	Total VMT	AM Peak VHT	Off Peak VHT	PM Peak VHT	Total VHT
Freeways	1,599,469	2,589,314	1,782,105	5,970,888	38,514	41,823	40,705	121,042
Expressways	443,209	707,603	501,299	1,652,111	10,675	12,350	11,508	34,532
Class I Arterials	532,414	776,657	649,412	1,958,483	18,851	20,818	24,591	64,260
Class II Arterials	464,114	630,947	532,734	1,627,795	17,224	17,866	19,988	55,079
Class III Arterials	174,377	242,449	206,712	623,539	6,442	7,836	7,891	22,169
Class I Collectors	157,198	217,849	194,622	569,669	5,814	7,475	7,515	20,804
Class II Collectors	233,009	324,016	284,288	841,312	8,874	11,567	11,183	31,625
Local Streets	75,490	105,305	87,781	268,577	3,369	4,676	4,025	12,069
High Speed Ramps	78,038	139,623	82,520	300,182	2,309	3,281	2,632	8,221
Low Speed Ramps	38,044	81,042	48,957	168,043	3,755	5,803	6,632	16,190
Total	**3,795,363**	**5,814,805**	**4,370,431**	**13,980,599**	**115,827**	**133,495**	**136,670**	**385,992**

Table 7. Conical VDFs' 2030 Transit Alternative VMT & VHT

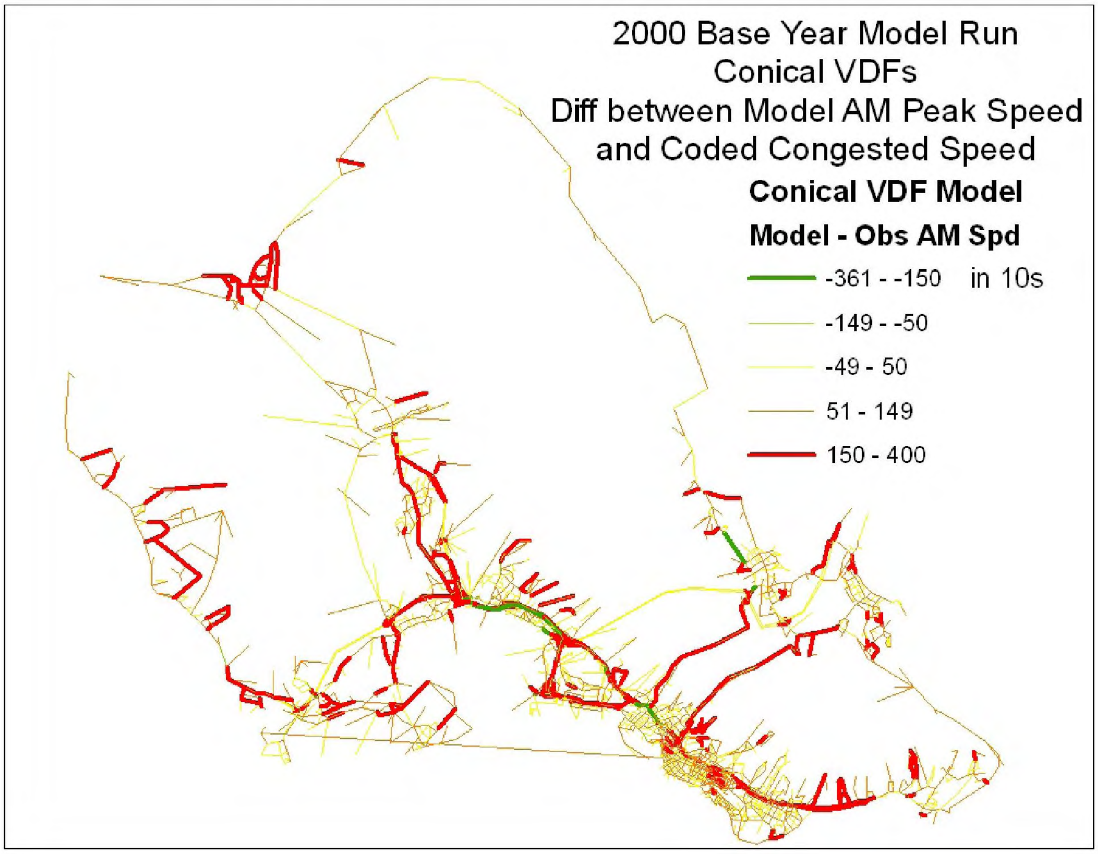
Facility Type	AM Peak VMT	Off Peak VMT	PM Peak VMT	Total VMT	AM Peak VHT	Off Peak VHT	PM Peak VHT	Total VHT
Freeways	1,606,050	2,582,639	1,777,862	5,966,551	36,601	41,609	41,195	119,404
Expressways	440,499	703,647	501,856	1,646,002	10,339	12,166	11,454	33,959
Class I Arterials	536,474	786,254	658,388	1,981,116	18,229	20,657	24,098	62,984
Class II Arterials	459,036	636,882	532,508	1,628,425	16,076	17,653	18,646	52,375
Class III Arterials	175,034	246,059	210,293	631,385	6,033	7,736	7,485	21,254
Class I Collectors	143,444	214,660	178,590	536,694	5,747	7,665	7,594	21,006
Class II Collectors	230,925	333,685	278,096	842,706	9,379	11,647	11,582	32,609
Local Streets	69,436	103,450	82,332	255,218	6,223	5,018	5,944	17,185
High Speed Ramps	90,684	142,804	92,460	325,948	1,713	2,714	1,755	6,182
Low Speed Ramps	35,162	83,098	41,910	160,170	3,991	5,856	7,508	17,355
Total	**3,786,743**	**5,833,176**	**4,354,296**	**13,974,215**	**114,333**	**132,721**	**137,260**	**384,314**

The following maps display the differences between the coded congested speed and the AM peak period congested speed from the 2000 base year model for each of the three different volume delay functions. Notice that Map 1 (Akçelik VDFs) has significantly more bold red links which means the model's speed is between 15 thru 40 mph faster than the observed speed compared to Map 2 (Conicals) and Map 3 (Curve table). This is especially the case in the downtown area.

Map 1. Difference between Model AM Congested Speed and Observed Congested Speed with Akçelik Volume Delay Functions



Map 2. Difference between Model AM Congested Speed and Observed Congested Speed with Conical Volume Delay Functions



Map 3. Difference between Model AM Congested Speed and Observed Congested Speed with Curve Table Volume Delay Functions

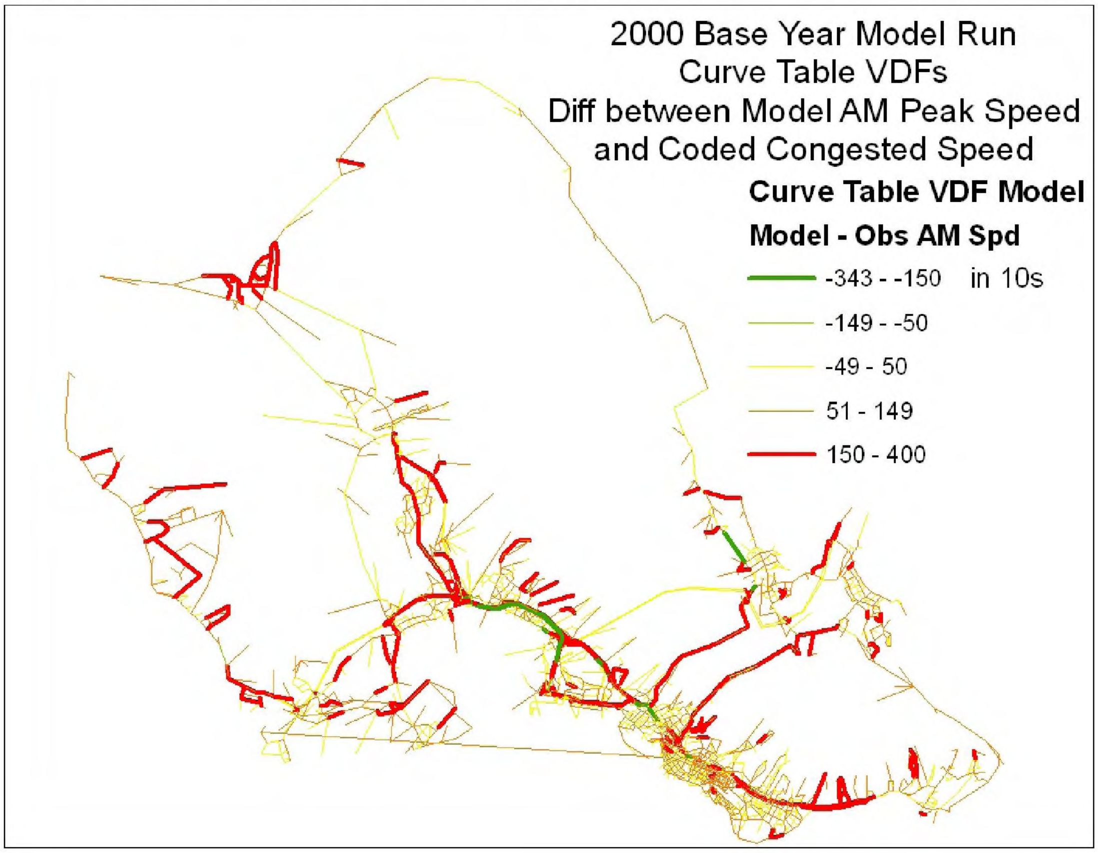


Table 8. 2000 Base Year Model Run V/C and Corresponding Speeds for Various Screenline Locations

	Model w/Akçelik VDFs					Model with Conicals					Model with Curve Table			
	WB	EB	WB	EB		WB	EB	WB	EB		WB	EB	WB	EB
	VC		SPEED			VC		SPEED			VC		SPEED	
University Avenue ‘Ewa of UH Campus														
am	31	75	34	33.8		30	73	32.3	26.6		33	93	32.6	28.2
op	31	42	34	34		26	34	32.6	32		34	47	32.6	32
pm	47	57	34	33.9		44	52	31.1	30.3		65	66	31.1	31.1
Nimitz Highway at Kapālama Stream														
am	42	106	37	18.1		45	104	33.8	16.6		43	115	32.9	11.3
op	14	15	37	37		19	20	35.98	35.9		21	16	35.1	35.5
pm	105	82	19.2	36.9		104	76	16.7	28		85	77	23.3	25.6
Kapi‘olani Boulevard near Pi‘ikoi Street														
am	21	85	32	31.7		26	53	30.7	28.3		31	59	29.8	26.1
op	10	20	32	32		10	21	31.6	30.9		10	20	31.4	30.4
pm	31	36	32	32		54	41	28.3	39.6		57	42	26.3	28.5
Ala Moana Boulevard near Pi‘ikoi Street														
am	57	66	35	34.9		55	62	30.9	29.7		47	65	30.7	27.5
op	17	17	35	35		21	21	34	34		23	18	33.3	33.7
pm	81	74	34.9	34.9		74	62	27.1	29.6		67	61	27	28.1
South King Street near Pi‘ikoi Street														
am		46		35			50		31.4			46		30.9
op		19		35			19		34			17		33.6
pm		67		35			64		29.3			62		27.9
Dillingham Boulevard at Kapālama Stream														
am	32	104	34	20.2		32	106	32.3	14.4		30	100	31.3	14.2
op	10	20	34	34		13	21	33.4	33		11	18	33	32.4
pm	101	73	25.4	33.8		90	77	21.2	25.6		82	64	21.2	25.5
H-1 Freeway at Kapālama Stream														
am	91	97	64.8	64.4		82	101	52.6	31.5		82	83	50.3	49.9
op	83	65	65	65		70	64	57.8	59.1		71	68	57.4	58.5
pm	92	89	64.8	64.8		95	86	40.8	50.1		97	80	30.9	51.5
North King Street at Kapālama Stream														
am	22	109	35	12.3		24	100	33.8	17.4		31	82	32.7	22.8
op	10	19	35	35		13	21	34.4	33.9		13	18	34	33.7
pm	94	46	34	34.9		89	60	22.3	30.1		86	60	21.8	28.4

Like the above Maps show, the Table above shows much slower speeds with conical and curve table volume delay functions.

3.6 Conclusions

The conical and curve table volume delay functions have shown that speeds degrade gradually compared to the Akçelik curve function. The conical and curve table functions also match observed congested speeds during the peak periods more closely compared to the Akçelik functions. Because equations (Conical functions) are easier to work with compared to the look up tables (Curve table vdfs), we recommend replacing the Akçelik functions with the conical functions over the curve table volume delay functions in the OMPO travel demand model.

4.0 Examination of Variations in Speed Table/Free Flow Speed Assumptions

4.1 Introduction and Summary

Recent testing of the Oʻahu Metropolitan Planning Organization (OMPO) travel demand for use in the Alternatives Analysis (AA) for the City and County of Honolulu high-capacity transit project on Oʻahu revealed potential issues with selected free-flow highway speeds currently coded in the model.

The issue revealed itself in evaluations of transit paths between leeward/central Oʻahu and Downtown Honolulu. During one of these evaluations, transit passengers were found to ride a generic fixed guideway mode to a station located just short of Downtown. They then transferred to local bus mode for completion of the trip into Downtown Honolulu, because doing so would yield the shortest travel time. When speeds were checked, it was found that the local buses were traveling at significantly higher speeds than those observed today. This was due to relatively high modeled speeds on the arterial/collector roadways within the Downtown/Urban Core area of Honolulu.

Some of this was believed to be caused by the Akçelik volume-delay functions (vdfs) that maintained relatively high speeds up to high volume/capacity (v/c) ratios, reducing speeds abruptly only after v/c ratios reached values over 1.00. Therefore, the Akçelik vdfs were replaced with conical functions. A separate technical memorandum discusses this proposed change to the travel demand model.

Even the substitution of the conical vdfs did not eliminate the issue of local buses traveling at unrealistically high speeds in the Downtown and urban core areas. Unless these roadway links were significantly congested, the vdfs did not reduce speeds to observed levels. It is believed that these relatively high roadway speeds result because the travel demand model codes relatively high free-flow speeds for selected roadway links within the Downtown/Urban Core area.

To test this hypothesis, speed surveys were conducted over two weekdays on major roadway facilities within the Downtown/Urban Core area. It was found that the actual average vehicular speeds (including stops for traffic signals) during the midday off-peak time period were between 5 and 15 mph less than the coded free flow speed. Additionally, it was found that the modeled speeds on these facilities were faster than the observed speeds for the AM peak, midday off peak, and PM peak time periods.

As a result, a recommendation is made to reduce the coded free flow speed in the OMPO travel demand model for selected facility types in the Downtown/Urban Core area of Honolulu.

4.2 Description of the Area of Free Flow Speed Adjustments

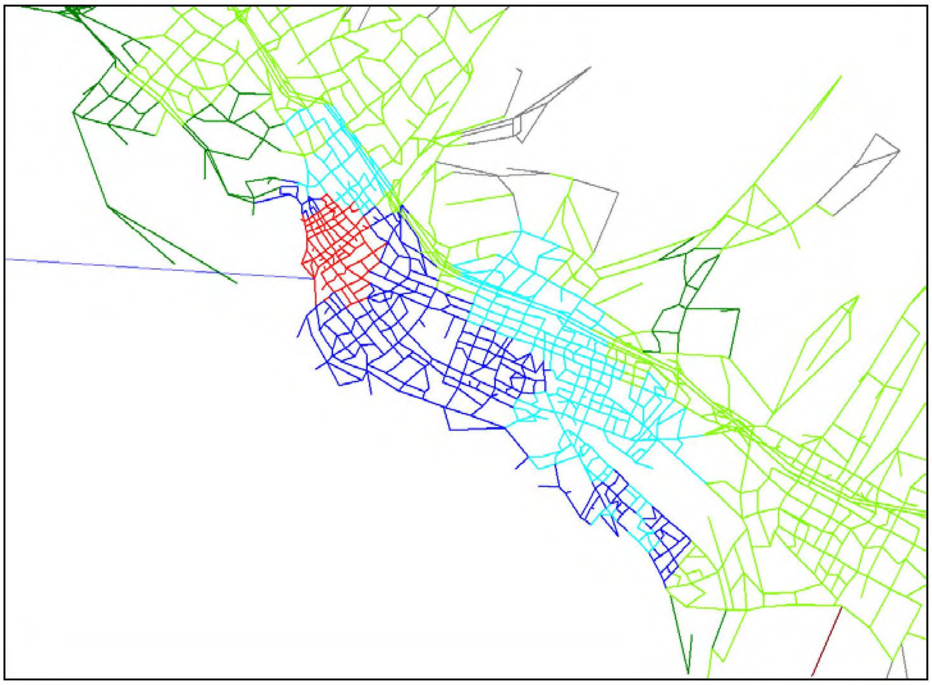
The adjustments to the coded free flow highway speeds are located in the part of the study corridor that extends from Pālama Street on the west side, through Downtown, to approximately the edge of Kaimukī/Kapahulu on the east side. This area includes Pālama, Chinatown, Downtown, Kakaʻako, Ala Moana, Waikīkī, Makiki, McCully, and Moʻiliʻili.

Figure 2-3 illustrates the roadways designated as Area Type 1 (CBD), 2 (Core Commercial), and 3 (Core Residential). It is the non-freeway roadways in these areas types that area proposed for reduction in coded free-flow speed.

The non-freeway roadways coded in red, dark blue, and cyan are proposed to have their free-flow speeds reduced. The colors represent the following area types:

- Red — Area Type 1 — Central Business District
- Dark Blue — Area Type 2 — Core Commercial
- Cyan — Area Type 3 — Core Residential

Figure 2-3
Area of Proposed Free Flow Speed Adjustments



Traffic flow in this area is strongly regulated by traffic signals. Even in low traffic demand time periods, the at-grade intersections on the arterial and collector roadway system constrain the average speeds that can be achieved by vehicles.

4.3 Evaluation of Highway Speeds

4.3.1 Methodology

Observations of existing highway speeds were conducted on Wednesday, January 25, 2006 and Thursday, January 26, 2006. Observations were conducted using the floating car method with observers driving pre-defined routes and recording travel times between checkpoints. The travel times were used with distances between checkpoints to calculate average vehicle speeds. These average speeds include time spent waiting at traffic signals.

Two arterial roadway corridors were sampled:

1. South King Street/Beretania Street;
2. Kapiʻolani Boulevard.

The roadway corridors traversed the area between Downtown Honolulu and the western edge of Kaimukī.

4.3.2 Evaluation Results

South King Street/South Beretania Street Corridor

Figures 3-1 and 3-2 illustrate speeds on the South King Street/South Beretania Street corridor in the east and westbound directions, respectively. These two one-way streets operate as a couplet with South King Street serving the eastbound traffic and South Beretania Street serving the westbound traffic. Three time periods were sampled: AM commuter peak, PM commuter peak, and midday off-peak.

The graphs show both observed and modeled speeds for the three time periods. As shown, the observed speeds are significantly lower than the modeled speeds. The graphs also illustrate the coded free-flow speed used by the travel demand model. With a few exceptions, the modeled speeds are only slightly less than the coded free-flow speed, even using the revised conical volume delay functions (vdfs). The observed speeds are between 5 and 15 mph less than the modeled speeds.

Additionally, it was found that average vehicle speeds during the midday off-peak time period were also less than the coded free flow speeds.

Based on these observations and results, it is believed that 25 mph would be a more realistic free flow speed for these area types.

Figure 3-1
Eastbound Speeds in South King Street/South Beretania Street Corridor

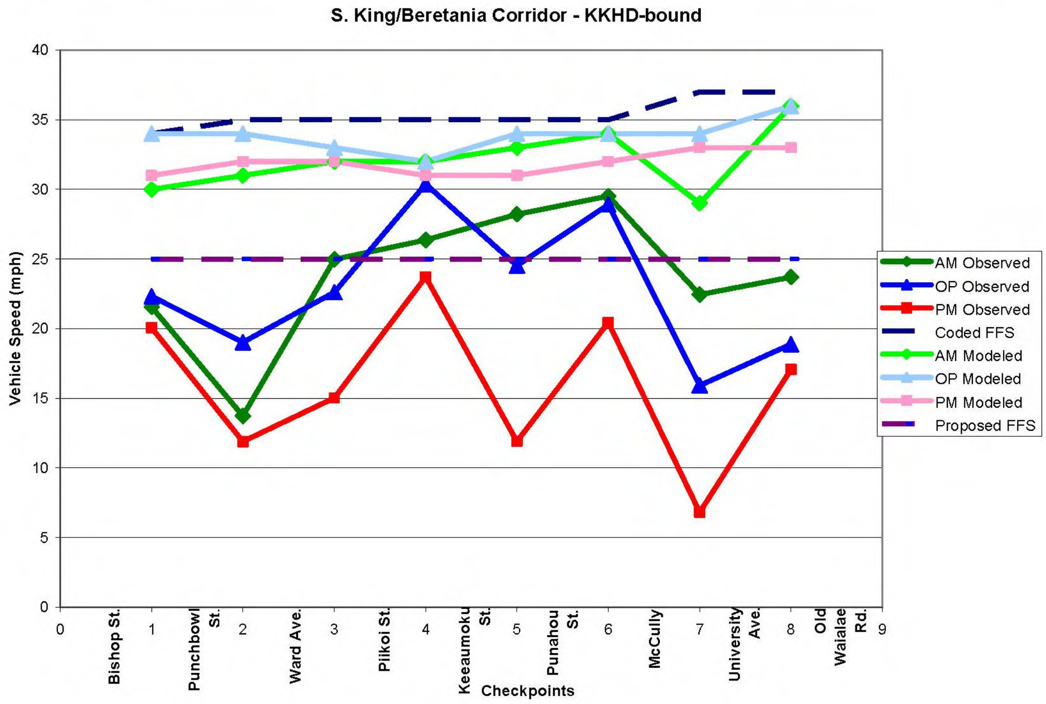
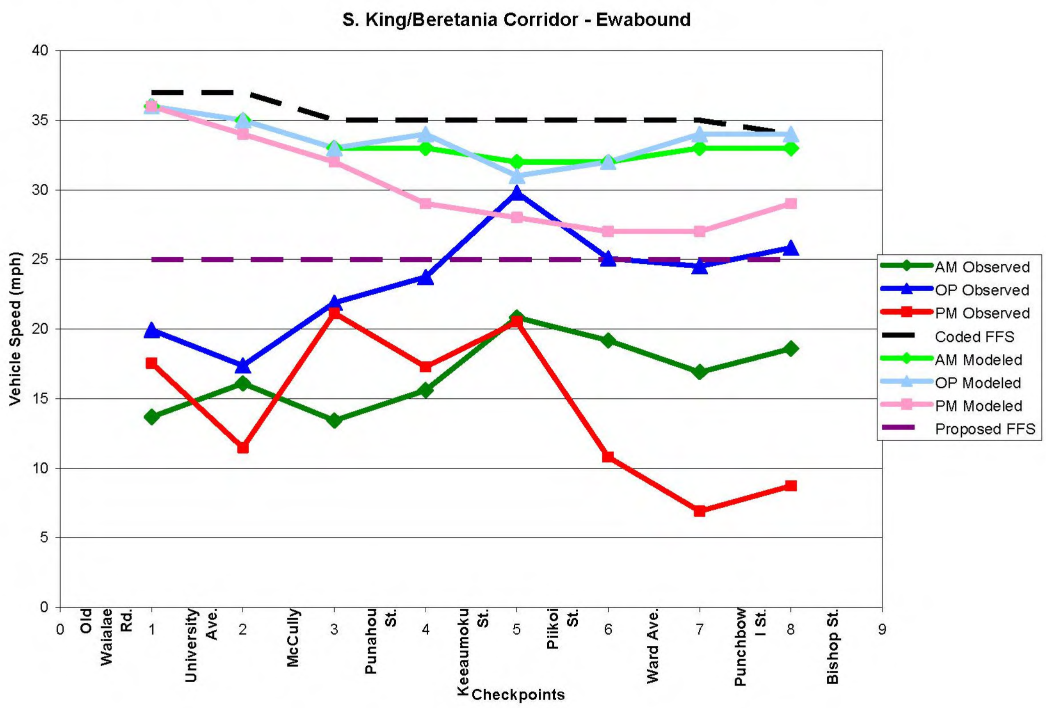


Figure 3-2
Westbound Speeds in South King Street/South Beretania Street Corridor



Kapiʻolani Boulevard Corridor

Figures 3-3 and 3-4 illustrate speeds on the Kapiʻolani Boulevard corridor in the east and westbound directions, respectively. Three time periods were sampled: AM commuter peak, PM commuter peak, and midday off-peak.

These graphs also show that the modeled speeds are only slightly less than the coded free-flow speeds while the observed speeds are between 5 and 15 mph less than the modeled speeds.

As in the South King Street/South Beretania Street corridor, observed average vehicle speeds during the midday off-peak time period were significantly lower than the coded free flow speeds.

The results in the Kapiʻolani Boulevard Corridor also support the suggestion to set coded free flow speeds to 25 mph.

Figure 3-3
Eastbound Speeds in Kapiʻolani Boulevard Corridor

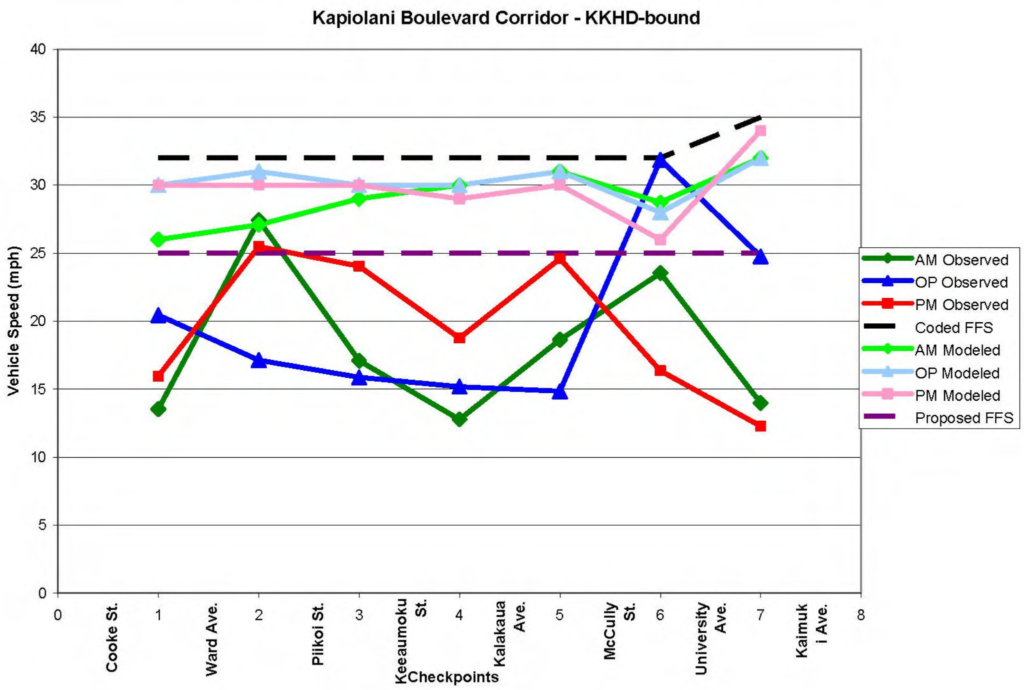
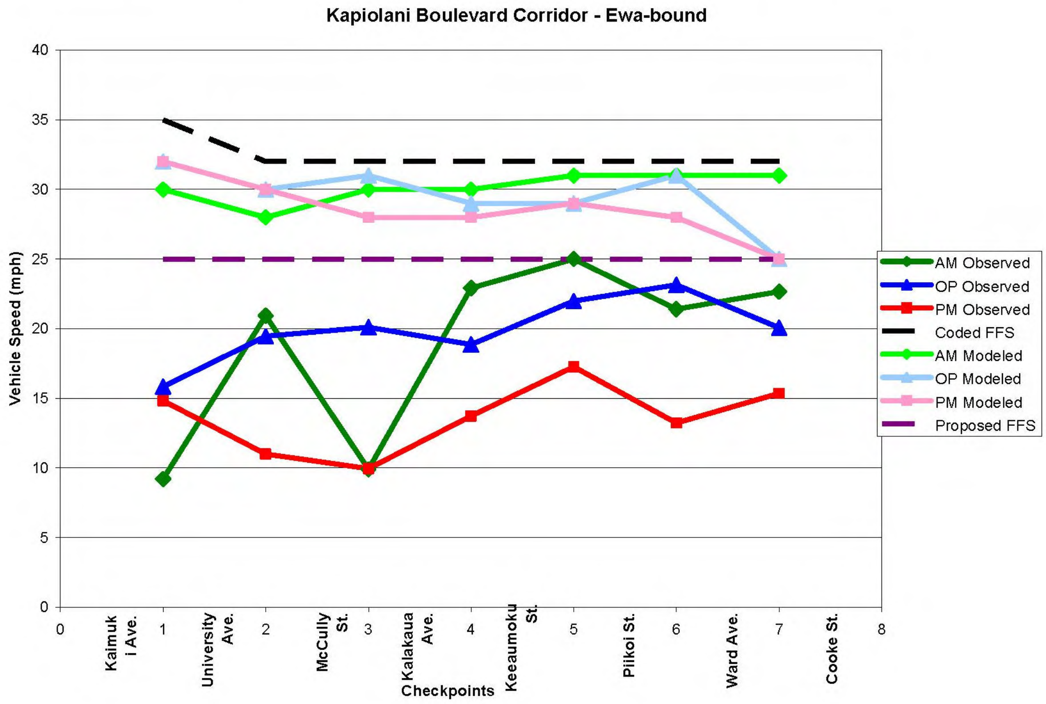


Figure 3-4
Westbound Speeds in Kapi'olani Boulevard Corridor



4.3.3 Recommended Action

Based on the results of the speed surveys on the South King Street/South Beretania Street and the Kapiʻolani Boulevard arterial roadway corridors, it is recommended to modify the model free flow speed table to code lower speeds for selected roadway facility types for area types 1, 2, and 3.

Figure 3-5 shows the free flow speeds coded into the Oʻahu Metropolitan Planning Organization (OMPO) model roadway links by area type and facility type.

Figure 3-5
OMPO Travel Demand Model Free Flow Speeds

Area Type	CBD	Core Commercial	Core Residential	Urban Commercial	Urban Residential	Suburban Commercial	Suburban Residential	Rural
Facility Type								
Freeway	60	63	63	65	65	68	68	68
Expressway	54	57	58	59	60	60	63	63
Class I Arterial	34	35	35	37	37	41	45	47
Class II Arterial	30	32	32	34	35	40	42	47
Class III Arterial	28	30	30	32	33	37	40	47
Class I Collector	26	28	28	30	30	35	39	46
Class II Collector	24	26	27	28	28	33	38	45
Local Street	12	17	18	19	20	25	30	32
High Speed Ramp	50	50	51	51	52	52	55	57
Low Speed Ramp	25	30	30	30	30	35	35	37
Centroid Connector	12	17	18	19	20	25	30	32

It is recommended to modify all of the free flow speeds in the shaded area to 25 mph. Doing so will bring the speeds on these facilities more in line with the observed average travel speeds on these roadways.

5.0 Review of Transit Travel Time Functions

5.1 Introduction

The transit travel time functions were estimated based on the base year 1996 transit network schedule times between timepoints. The estimated times were gathered from the calculated transit link times (from the base year 1996 model) and converted to the equivalent transit segments defined by the timepoints from the observed data. Segments were classified by facility type, though in many cases a segment included more than one facility type. This analysis was done in December 2002. The transit travel time functions used in the OMPO model are simply factors that are applied to the congested highway travel times to represent transit times. For freeways, expressways and ramps, these factors are set to 1 since no stops are generally made along these facilities. Table 1 shows the resulting set of factors.

Note also that a 0.17 minute (about 10 seconds) dwell time penalty was applied to each transit link to represent time spent serving passenger access and egress at stops. Since the schedule time is being used as the basis for comparison, this dwell time is included in the comparisons, but only the actual link speed is adjusted by the transit time factor. The computed transit travel time factors were applied by facility type during transit path building. Table 1 shows these factors. Figures 1 and 2 show the initial observed and estimated transit segment time comparisons by facility type. While there is much scatter to the data (average r-square of 0.40, correlation of 0.65) the overall average speeds were modeled as well as possible given the single multiplicative transit travel time factor.

The factors shown in Table 1 were updated to reflect the use of the Conical VDFs rather than the Akçelik curves used originally. These factors currently await final adjustments, but they typically reflect a 40 to 80 increase in transit travel time over the average speed of traffic, due to stops, wait time and vehicle performance characteristics including to speeds acceleration and deceleration rates.

Table 1: Transit Link Time Factors

Facility	Peak (based on AM Peak)	Off-Peak
Freeways and Expressways	1.0	1.0
Ramps	1.0	1.0
Art I	1.53	1.59
Art II	1.48	1.77
Art III	2.38	1.60
Coll I	1.46	1.82
Coll II	2.75	2.16
Local	1.10	1.56

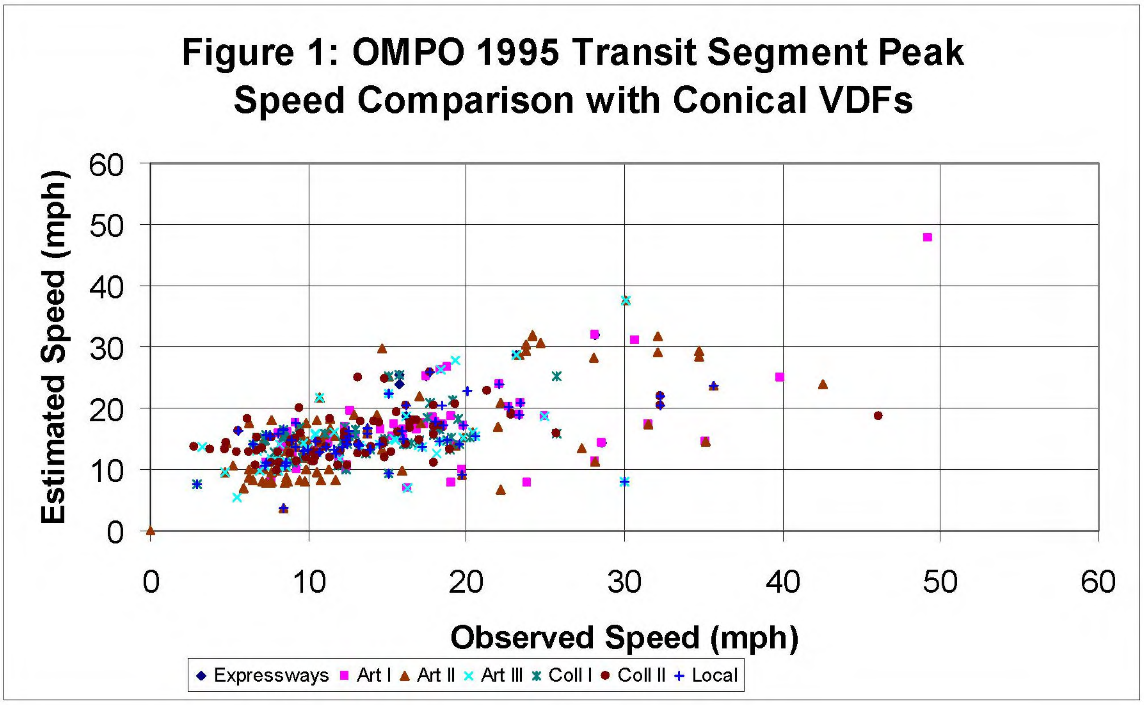


Figure 1: OMPO 1995 Transit Segment Peak
Speed Comparison with Conical VDFs
Estimated Speed (mph)
Observed Speed (mph)
0
10
20
30
40
50
60
Expressways
Art I
Art II
Art III
Coll I
Coll II
Local

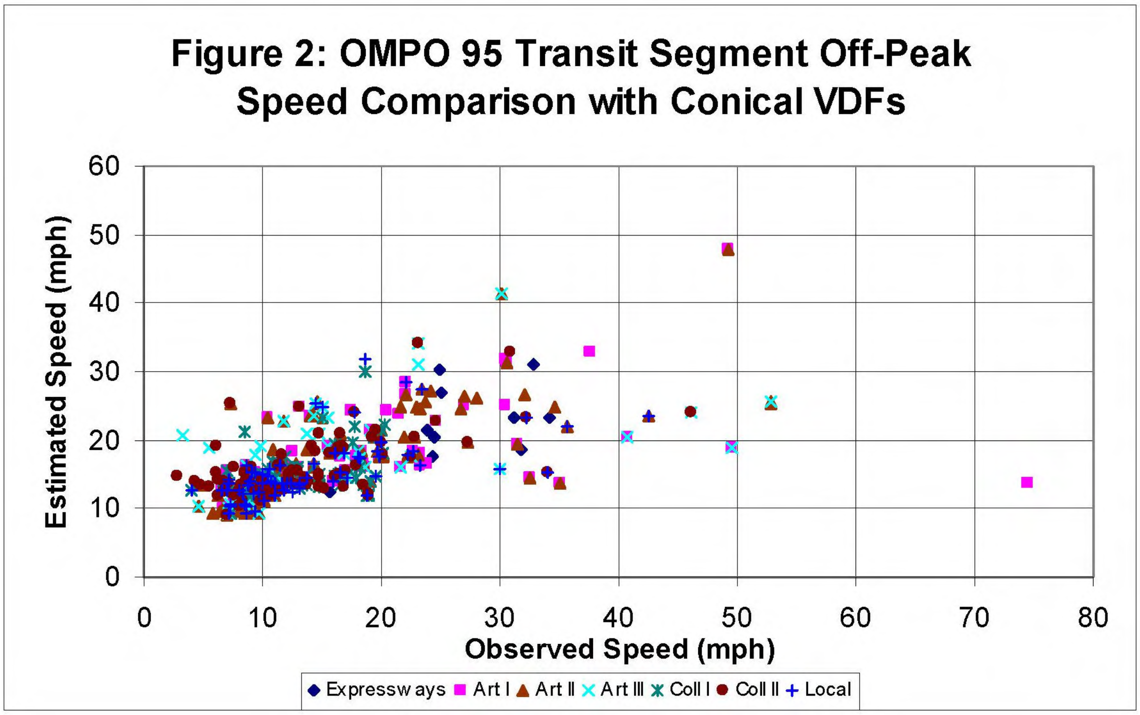
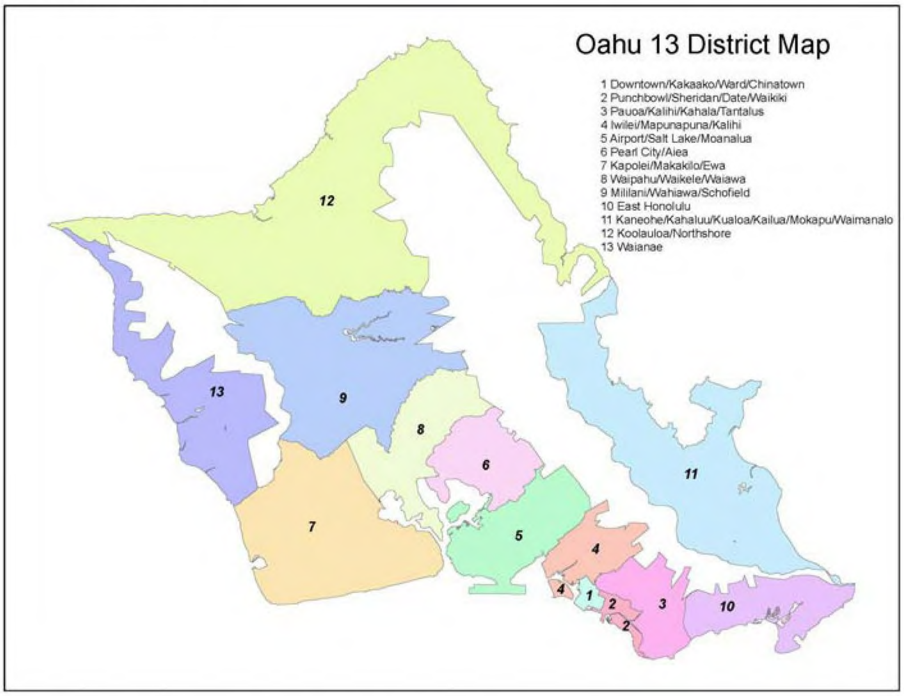


Figure 2: OMPO 95 Transit Segment Off-Peak
Speed Comparison with Conical VDFs
Estimated Speed (mph)
Observed Speed (mph)
0
10
20
30
40
50
60
70
80
Expressw ays
Art I
Art II
Art III
Coll I
Coll II
Local

6.0 Year 2000 CTTP Person Trip Matrix Comparisons

The 2000 CTTP Journey to Work trips were compared with the 2000 Year Model Run Journey to Work trips to see how well the district to district movements match.

13 District Map



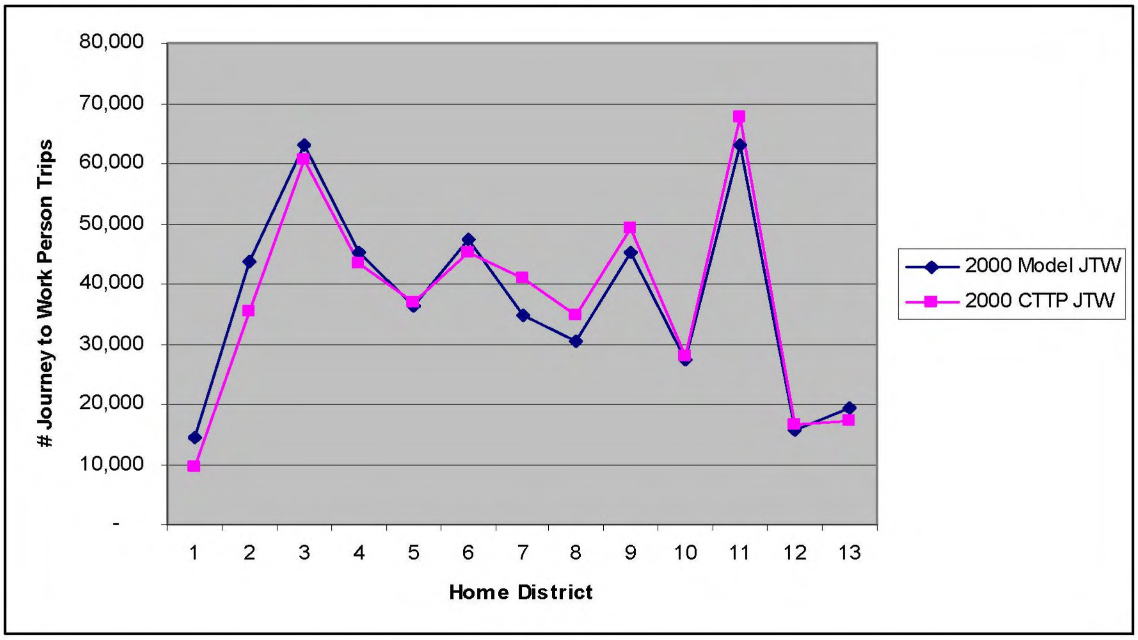
6.1 Person Trip Comparisons

Figure 1 below compares CTTP and 2000 Model Year Run Journey to Work person trips to the work place district. The model seems to be doing a pretty good job in terms of overall number of person trips to the different work districts.

Figure 1. Journey to Work Person Trips to Work District

Figure 2 compares the Journey to Work person trips from the Home location's district. Again, the model reflects similar proportions to the CTTP data.

Figure 2. Journey to Work Person Trips from Home District



The next several figures display the journey to work trips by mode and either from the home location's district, or to the work district. These figures show that the model not only is producing and attracting overall person trips correctly (as shown in Figures 1 and 2), but also accurately reflecting movements by mode (Figures 3 through 10).

Figure 3. Journey to Work Drive Alone Trips from Home District

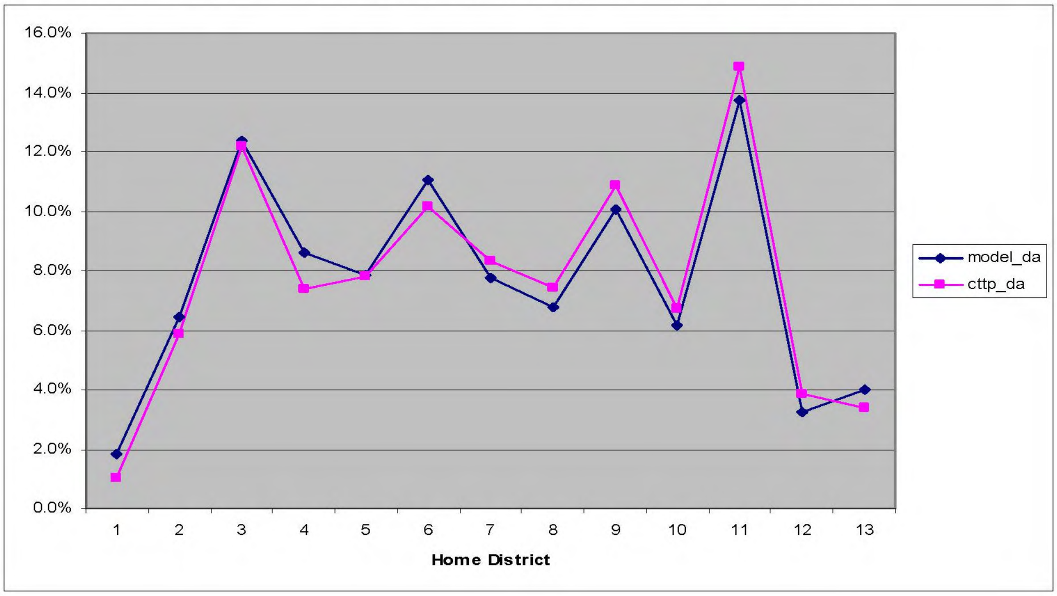


Figure 4. Journey to Work Drive Alone Trips to Work District

Figure 5. Journey to Work Shared Ride Trips from Home District

Figure 6. Journey to Work Shared Ride Trips to Work District

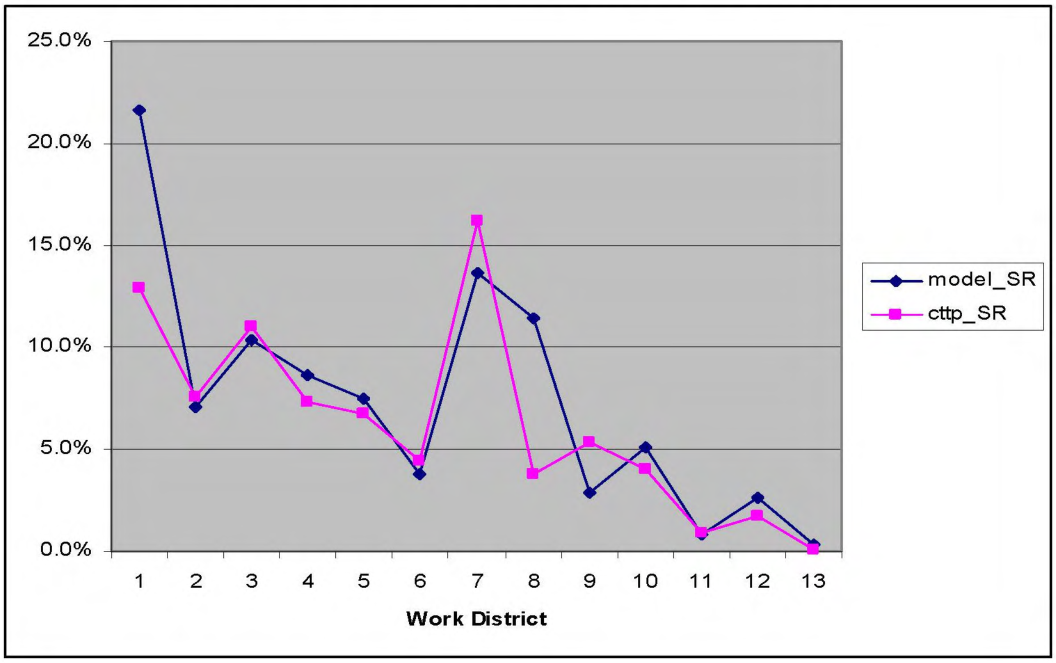


Figure 7. Journey to Work Transit Trips from Home District

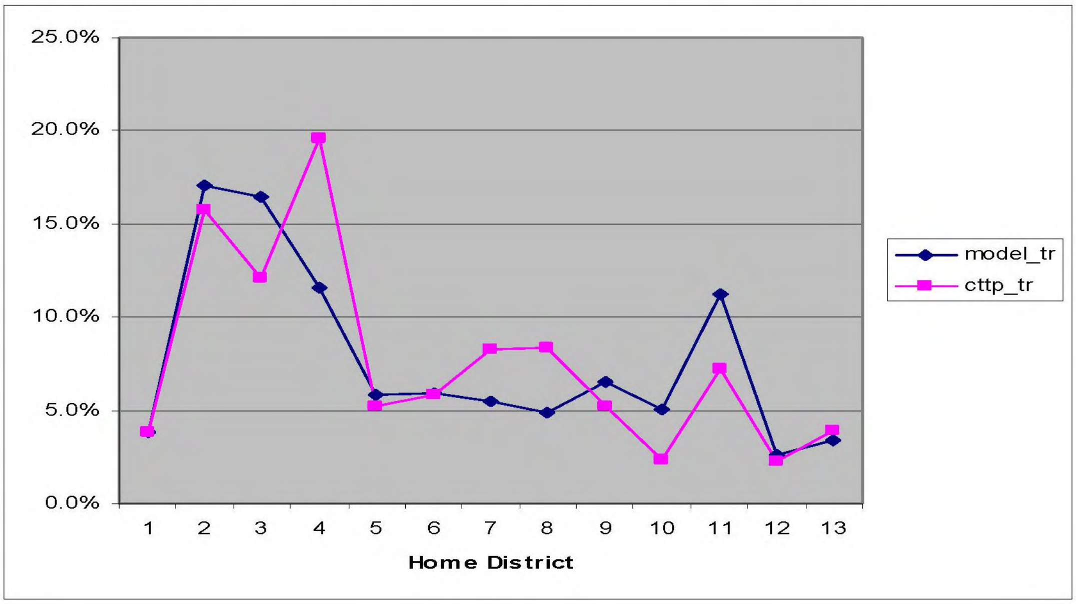


Figure 8. Journey to Work Transit Trips to Work District

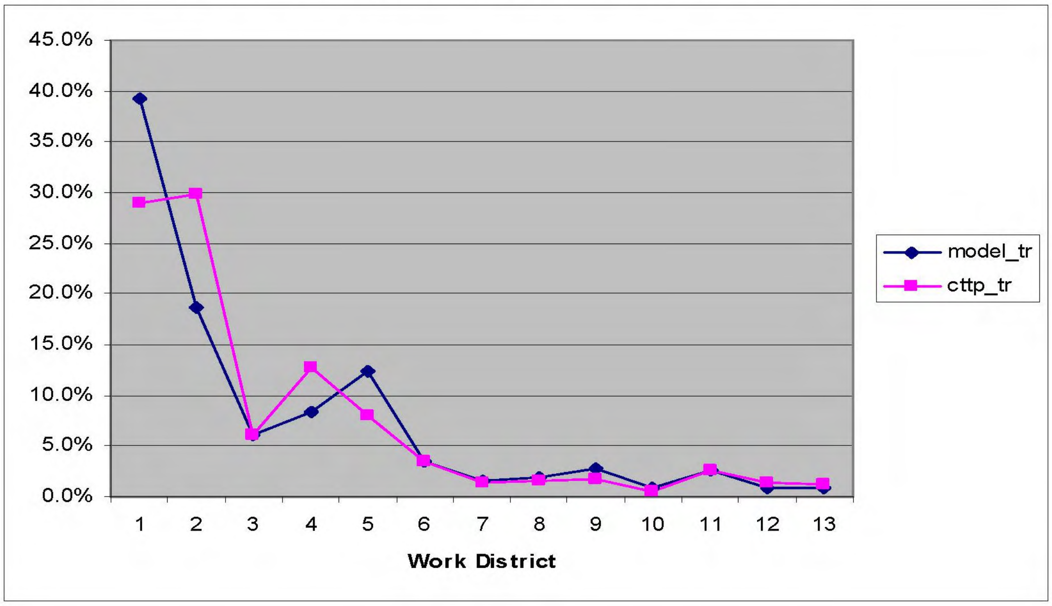


Figure 9. Journey to Work Auxiliary (Bike/Walk) Trips from Home District

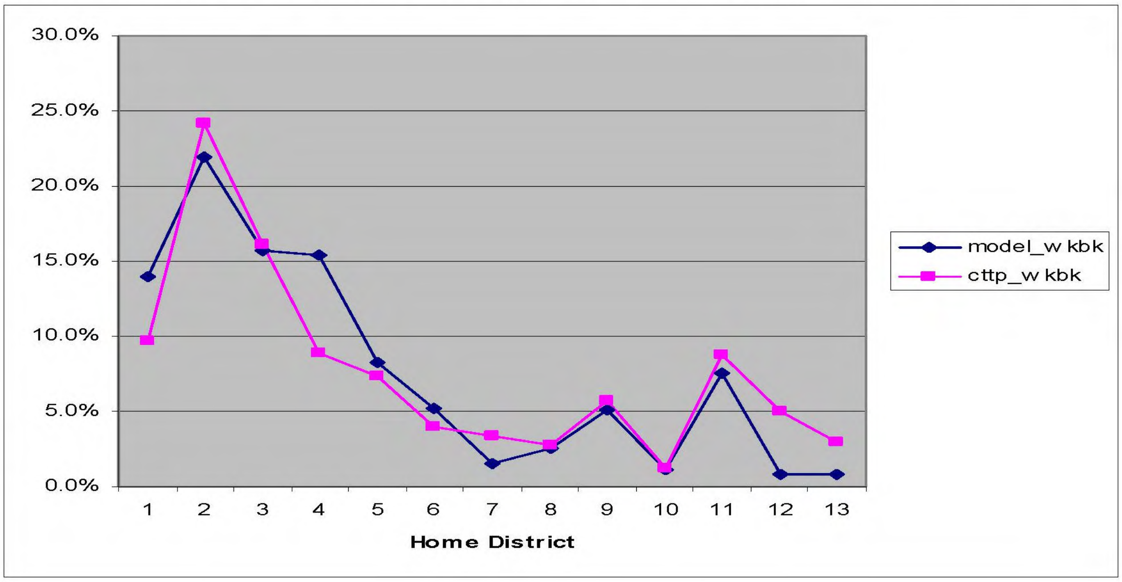


Figure 10. Journey to Work Auxiliary (Bike/Walk) Trips to Work District

6.2 District to District Movements

Table 1 below shows the district to district flows for journey to work person trips from the year 2000 ORTP OMPO Model. Table 2 shows the same information from 2000 CTTP but factored and normalized to the same total person trips from the 2000 OMPO model. And Table 3 shows the percent difference between Tables 1 and 2.

Table 1. Journey to Work Person Trips from 2000 Year ORTP OMPO Model

	Work District													
Home District	1	2	3	4	5	6	7	8	9	10	11	12	13	**Total**
1	6,807	2,801	982	1,865	1,255	211	41	45	59	69	189	15	3	**14,342**
2	12,431	17,020	6,159	3,264	2,962	505	108	136	154	396	464	45	18	**43,662**
3	17,605	17,361	12,491	6,075	5,658	966	213	278	348	893	957	131	61	**63,037**
4	14,603	5,017	2,956	10,906	7,987	1,237	228	312	305	255	1,295	80	33	**45,214**
5	4,851	2,620	1,847	4,038	16,666	2,617	369	1,250	569	174	1,183	116	44	**36,344**
6	5,951	4,032	2,279	5,046	14,014	7,540	1,258	2,842	1,931	252	1,695	317	140	**47,297**
7	3,407	4,259	1,408	2,350	6,598	2,424	7,179	2,350	1,932	201	1,086	374	1,225	**34,793**
8	3,213	7,679	1,101	1,919	5,755	2,773	1,721	3,296	1,836	104	732	175	133	**30,437**
9	4,542	3,152	1,866	3,095	8,868	3,113	1,697	1,754	14,315	261	1,437	966	235	**45,301**
10	5,996	5,695	4,900	2,362	2,861	561	219	189	394	2,828	1,004	200	81	**27,290**
11	12,795	5,586	3,254	6,233	9,128	2,938	673	870	1,058	572	19,237	534	169	**63,047**
12	1,746	1,303	778	866	1,922	526	355	363	1,659	153	699	5,331	116	**15,817**
13	2,141	1,606	963	1,095	4,705	804	1,201	701	754	176	747	346	4,064	**19,303**
Total	**96,088**	**78,131**	**40,984**	**49,114**	**88,379**	**26,215**	**15,262**	**14,386**	**25,314**	**6,334**	**30,725**	**8,630**	**6,322**	**485,884**

Table 2. Factored/Normalized Journey to Work Person Trips 2000 CTTP

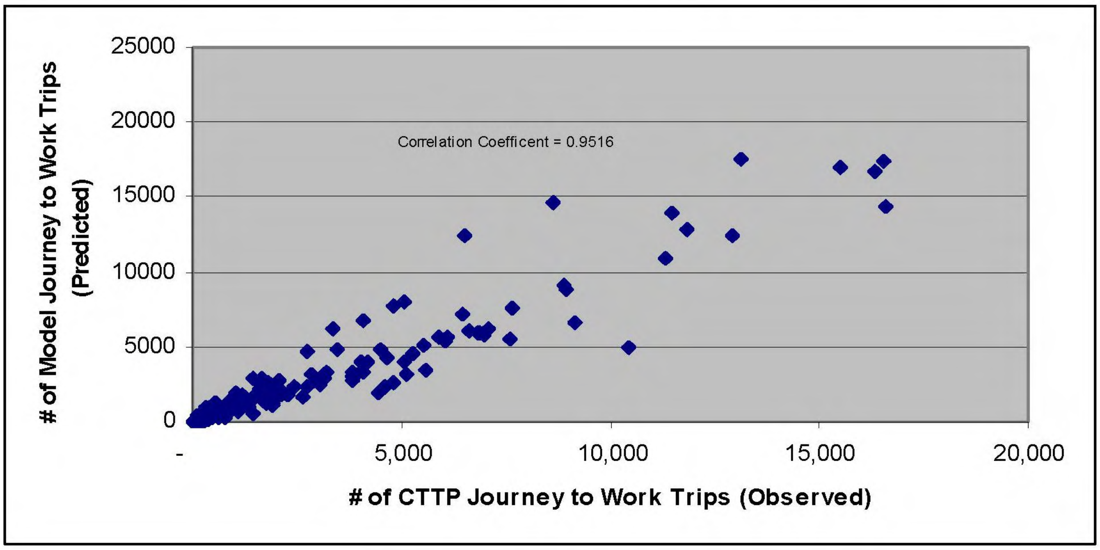
	Work District													
Home District	1	2	3	4	5	6	7	8	9	10	11	12	13	**Total**
1	4,077	2,089	551	1,013	832	222	74	65	189	29	271	19	32	**9,462**
2	6,533	15,504	3,351	3,848	3,158	555	321	333	283	489	758	167	148	**35,448**
3	13,112	16,537	12,927	6,606	5,896	1,034	628	596	636	835	1,356	224	166	**60,551**
4	8,629	10,428	3,151	11,295	5,086	1,116	765	460	422	423	1,070	347	252	**43,444**
5	4,491	4,783	1,551	4,037	16,335	1,788	504	592	1,435	133	1,099	176	87	**37,011**
6	6,869	5,051	2,042	5,531	11,474	7,665	1,733	1,659	1,559	210	1,119	163	256	**45,332**
7	5,560	4,631	1,420	4,625	9,160	3,074	6,439	2,417	1,915	141	915	172	538	**41,008**
8	5,134	4,785	1,193	4,419	6,973	3,011	1,582	4,080	2,119	244	738	241	364	**34,883**
9	5,290	3,926	1,641	3,825	8,955	2,822	1,858	2,263	16,577	154	878	551	465	**49,206**
10	6,841	6,094	3,488	2,733	3,030	548	241	185	363	3,823	650	97	52	**28,145**
11	11,836	7,587	3,224	7,067	8,867	1,463	885	782	817	806	23,593	565	102	**67,595**
12	1,188	901	391	1,120	1,642	596	474	383	2,625	93	1,099	6,070	79	**16,661**
13	1,593	1,507	314	1,904	2,720	1,053	1,917	896	552	76	314	91	4,199	**17,137**
Total	**81,152**	**83,823**	**35,243**	**58,023**	**84,128**	**24,947**	**17,421**	**14,710**	**29,494**	**7,458**	**33,861**	**8,884**	**6740**	**485,884**

Table 3. Comparison of Journey to Work Person Trips - Percent Difference

	Work District													
Home District	1	2	3	4	5	6	7	8	9	10	11	12	13	**Total**
1	67%	34%	78%	84%	51%	-5%	-45%	-31%	-69%	136%	-30%	-19%	-91%	**52%**
2	90%	10%	84%	-15%	-6%	-9%	-66%	-59%	-46%	-19%	-39%	-73%	-88%	**23%**
3	34%	5%	-3%	-8%	-4%	-7%	-66%	-53%	-45%	7%	-29%	-41%	-63%	**4%**
4	69%	-52%	-6%	-3%	57%	11%	-70%	-32%	-28%	-40%	21%	-77%	-87%	**4%**
5	8%	-45%	19%	0%	2%	46%	-27%	111%	-60%	30%	8%	-34%	-49%	**-2%**
6	-13%	-20%	12%	-9%	22%	-2%	-27%	71%	24%	20%	51%	95%	-45%	**4%**
7	-39%	-8%	-1%	-49%	-28%	-21%	11%	-3%	1%	42%	19%	117%	128%	**-15%**
8	-37%	60%	-8%	-57%	-17%	-8%	9%	-19%	-13%	-57%	-1%	-27%	-63%	**-13%**
9	-14%	-20%	14%	-19%	-1%	10%	-9%	-22%	-14%	69%	64%	75%	-49%	**-8%**
10	-12%	-7%	40%	-14%	-6%	2%	-9%	2%	9%	-26%	54%	107%	56%	**-3%**
11	8%	-26%	1%	-12%	3%	101%	-24%	11%	29%	-29%	-18%	-5%	65%	**-7%**
12	47%	45%	99%	-23%	17%	-12%	-25%	-5%	-37%	64%	-36%	-12%	46%	**-5%**
13	34%	7%	206%	-42%	73%	-24%	-37%	-22%	36%	130%	138%	280%	-3%	**13%**
Total	**18%**	**-7%**	**16%**	**-15%**	**5%**	**5%**	**-12%**	**-2%**	**-14%**	**-15%**	**-9%**	**-3%**	**-6%**	**0%**

Figure 11 below is a scatter plot of the 2000 model journey to work trips versus the 2000 CTTP journey to work trips. The 95% correlation coefficient shows that the predicted (model) district to district movements follow the observed district to district movements (CTTP data) quite well.

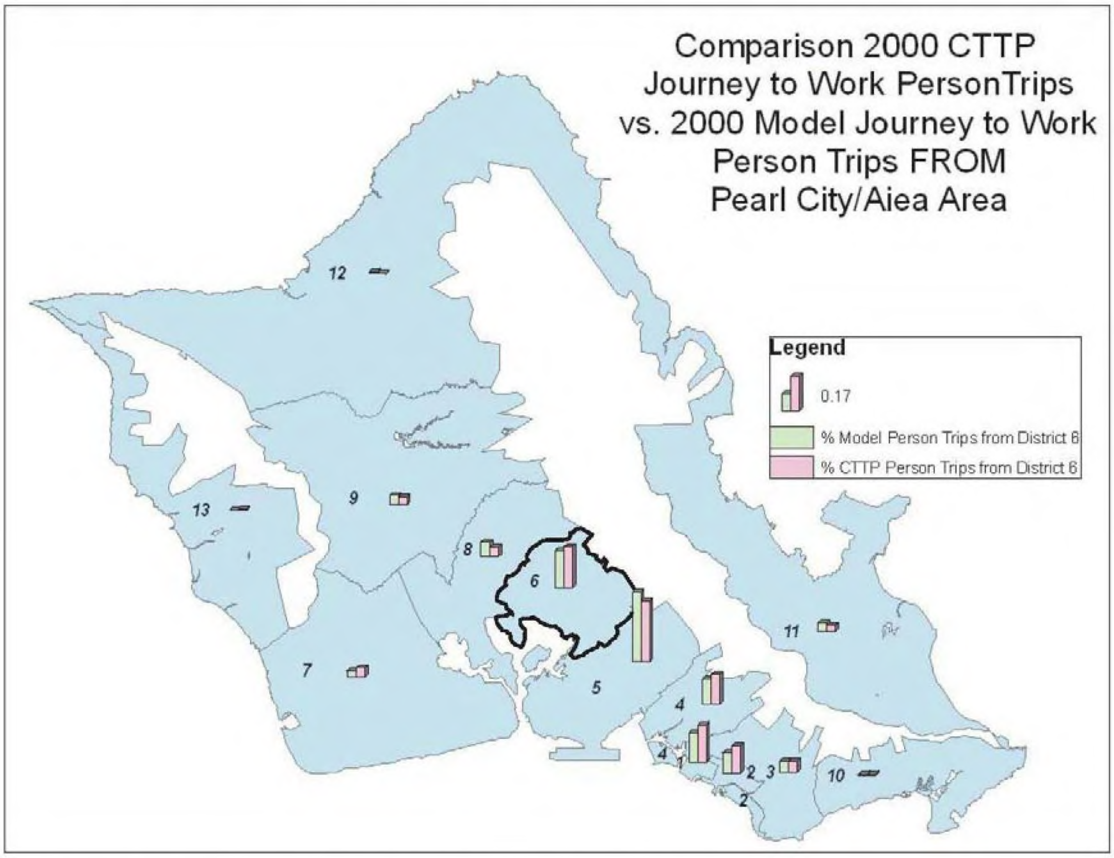
Figure 11. Correlation Plot of Journey to Work trips – Model vs. CTTP



To graphically show district to district movements, the next few maps look at several key home district areas and track where they go to work.

Map 1 compares 2000 CTTP and 2000 Modeled journey to work person trips of people living in the Pearl City/'Aiea area.

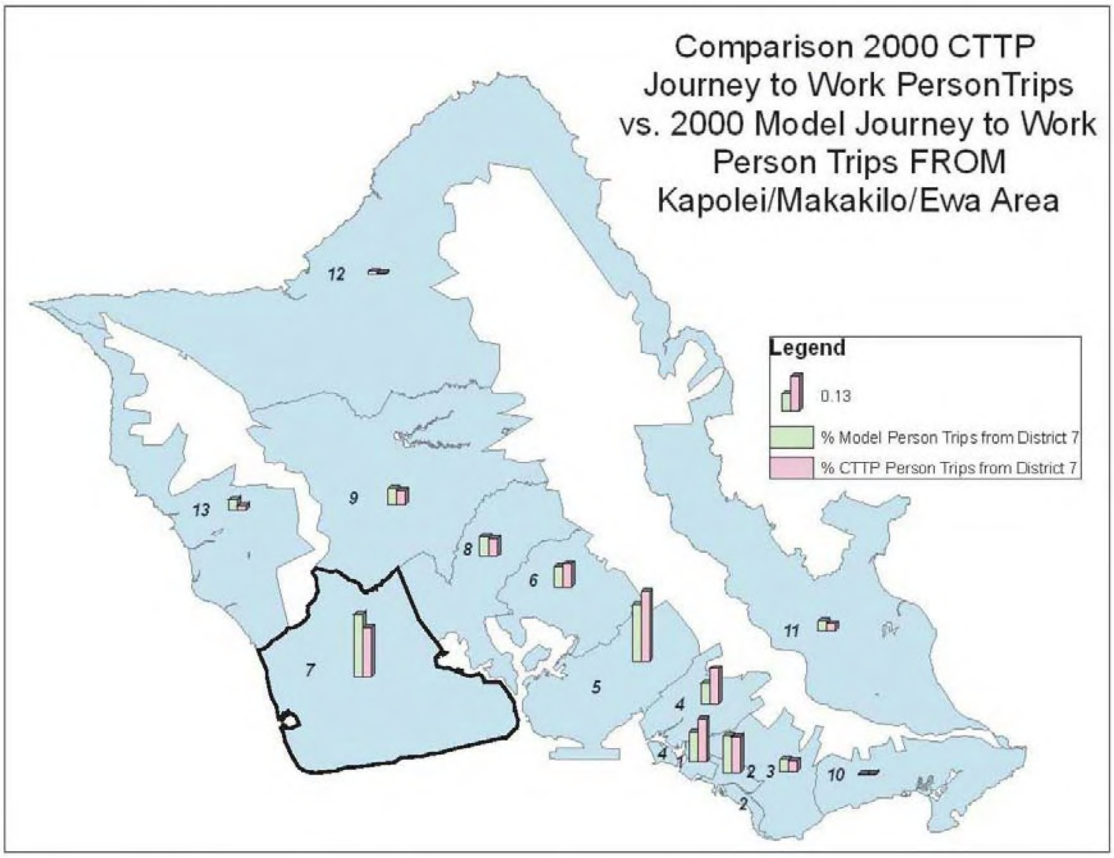
Map 1. Pearl City/'Aiea District 2000 CTTP vs. Model Person Trips to Work District



****Correlation Coefficient of trips ONLY from District 6 to All Districts = 97%**

Map 2 below compares journey to work person trips from the Kapolei/Makakilo/'Ewa area. The model seems to be attracting *slightly* more person trips to its own district (Kapolei/Makakilo/'Ewa district) compared to CTTP.

Map 2. Kapolei/Makakilo/'Ewa District 2000 CTTP vs. Model Person Trips to Work District

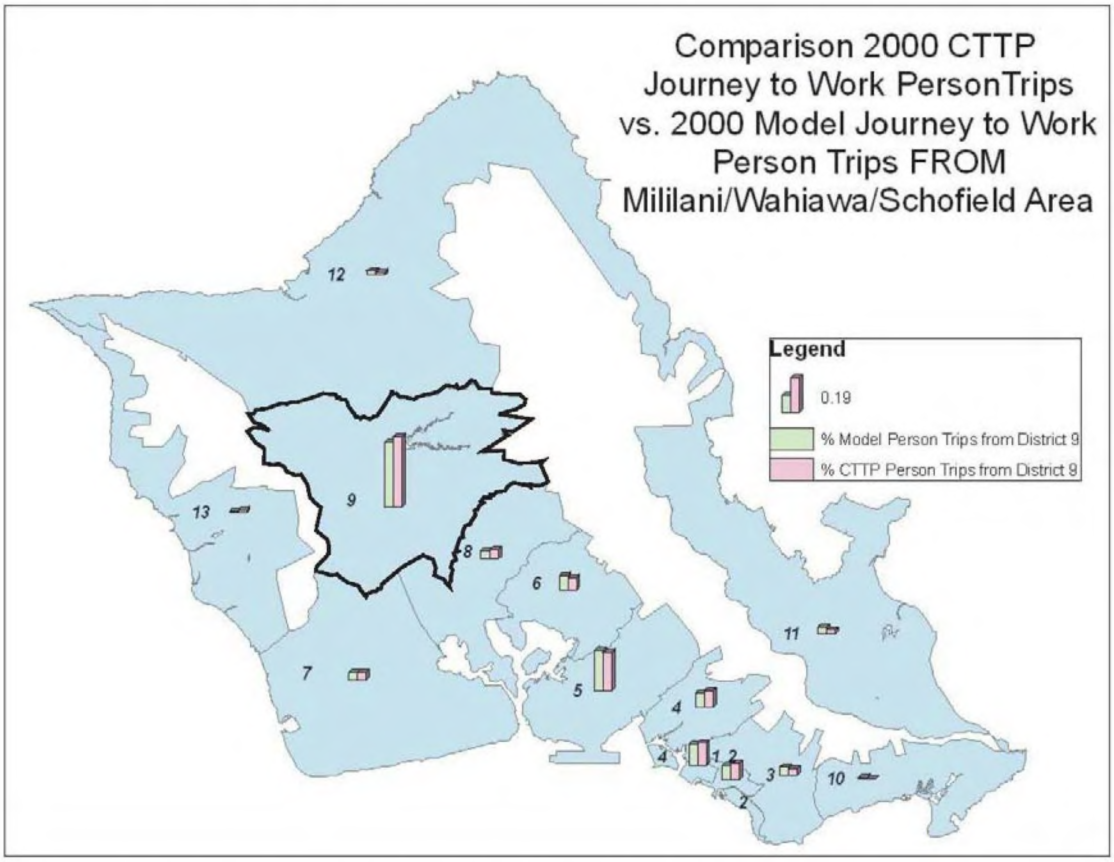


****Correlation Coefficient of trips ONLY from District 7 to All Districts = 92%**

AR00077121

Map 3 shows person trips coming from Mililani/Wahiawā/Schofield area. The model is attracting most person trips to the airport/Salt Lake/Moanalua district, and a good proportion to its own district.

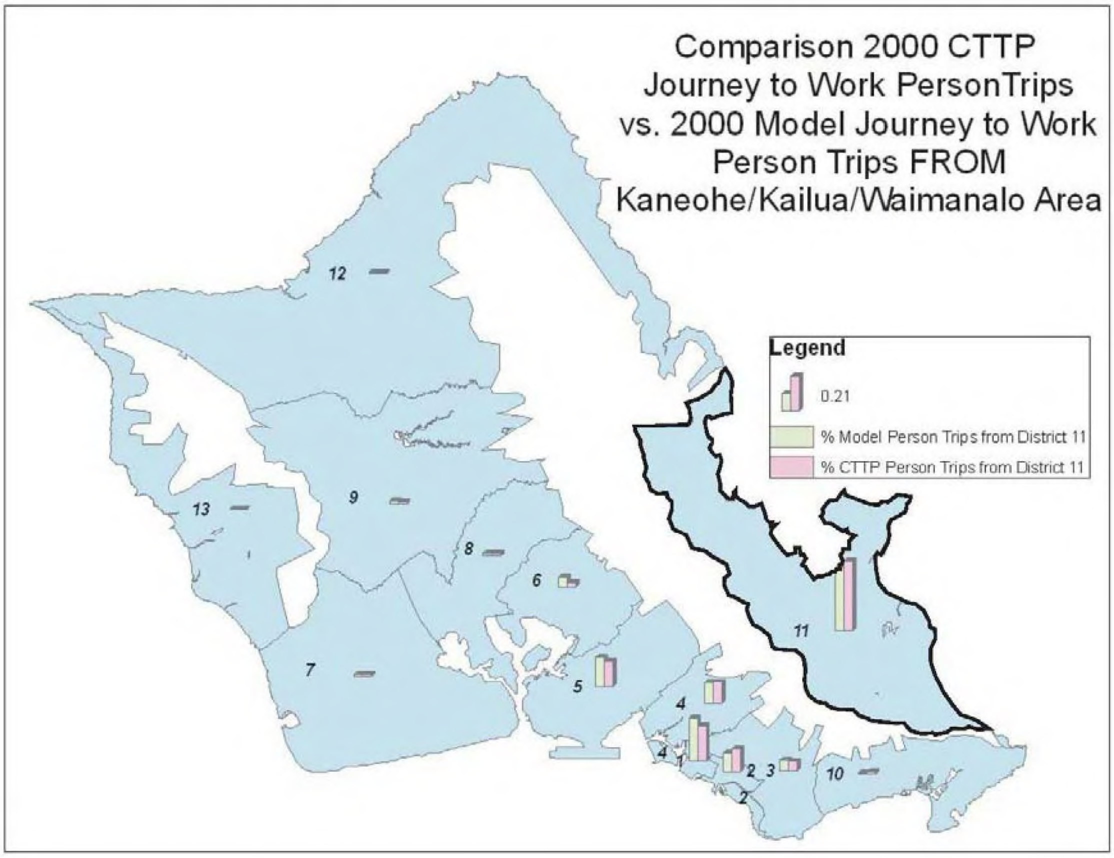
Map 3. Mililani/Wahiawā/Schofield District 2000 CTTP vs. Model Person Trips to Work District



****Correlation Coefficient of trips ONLY from District 9 to All Districts = 99%**

Map 4 shows person trips coming Kāne'ohe/Kailua/Waimānalo area. The model is doing a relatively good job at attracting the right proportion of person trips to the work districts.

Map 4. Kāne'ohe/Kailua/Waimānalo District 2000 CTTP vs. Model Person Trips to Work District



****Correlation Coefficient of trips ONLY from District 11 to All Districts = 98%**

6.3 Conclusions

The comparisons above between the 2000 CTTP and 2000 Model run data reveal that the model is doing a relatively good job at producing and attracting the correct proportion of person trips regionwide. Moreover, the model's distribution of trips by mode is also good. The figures above showing the trips by each mode produced to and attracted from each transportation analysis area between CTTP and Model are very good. The maps of CTTP and Model showing key areas' home locations' transit trips to work locations are also very comparable.

7.0 Evaluation of Parking Cost Representation and Forecasting

7.1 Introduction

This memorandum documents the parking costs used in the OMPO model, including their patterns and derivation, and a comparison with reported parking cost from HIS data. Since there is no parking cost model, parking costs must be provided exogenously to the model, and as such they have not been adjusted from the base year for future year conditions. This implicitly assumes that parking costs will keep pace with inflation over time, remaining constant in real dollars. This is a trend that has, in fact, been observed in Honolulu and elsewhere, as parking cost is directly influenced by a competitive supply and demand marketplace.

7.2 Model Representation of Parking Costs

The socioeconomic file contains non-zero parking costs for CBD and other core areas, as defined by area types 1, 2 and 3 (CBD, Core Commercial, Core Residential). Elsewhere, parking costs are set to 0. Only three unique non-zero values for parking cost are used for peak, and three for off-peak conditions. Table 1 shows the current parking costs used.

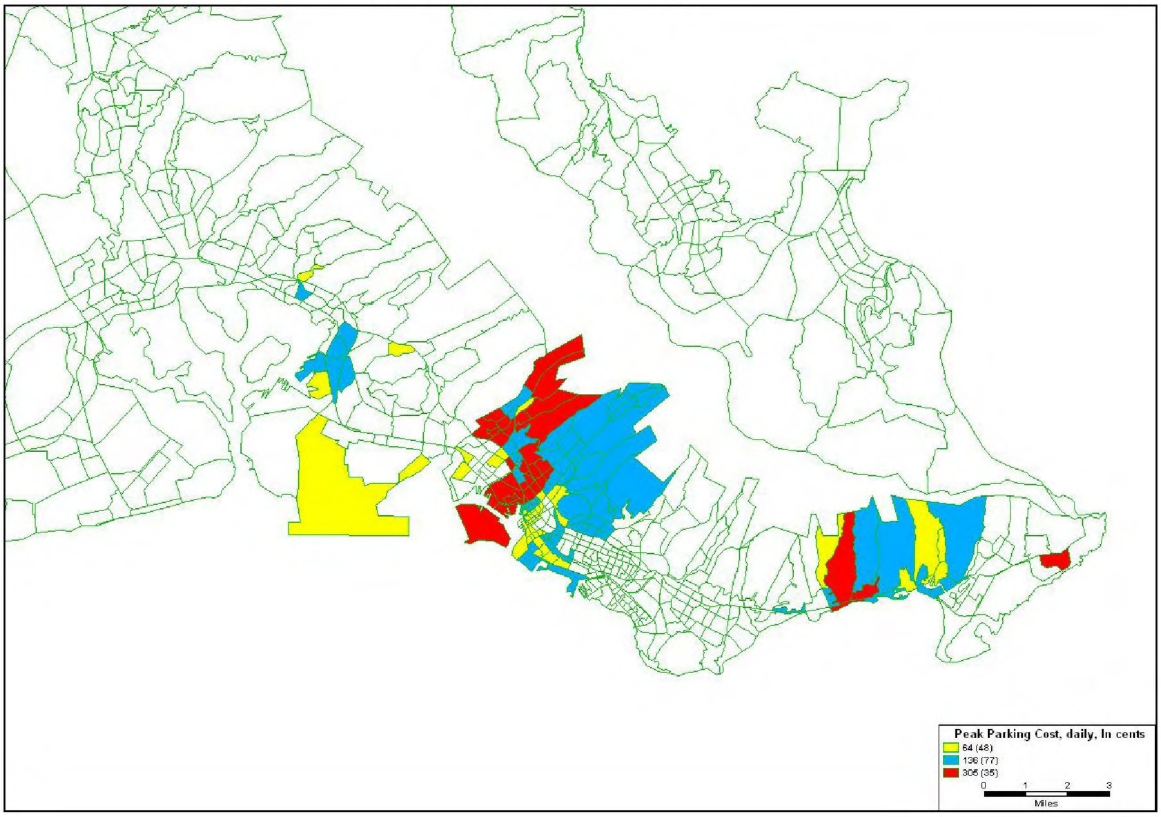
Table 1: Current OMPO Model Parking Costs (daily, in cents in 1995 dollars)

Area type	Peak Parking Cost	Off-Peak Parking Cost
CBD (Areatype=1)	305	76
Core Commercial (Areatype=2)	136	34
Core Residential (Areatype=3)	64	16

Note that the off-peak parking cost is ¼ of the daily parking cost. This is representative of an average 2 hour off-peak parking duration versus an 8-hour parking duration for work trips which occur in the peak time period.

Figure 1 shows a map of modeled parking costs by zone.

Figure 1 Modeled Parking Cost (peak, cents/day)



7.3 Parking Cost From HIS Data

The only source of observed, out-of-pocket parking cost data is the 1995 OMPO Home interview survey. As a part of the survey, each worker and student was asked to provide their usual parking costs for work and/or school (i.e., college). The question asked, "How much did you pay for parking?" and followed by questions related to employer or school subsidies, so it was clear that the cost requested was what the traveler paid directly. This information was codified in the person data section.

Parking cost data was extracted from the HIS using the following steps:

1. Identify person-records of persons that were students and/or employees, and had an opportunity to park at their work or school location.

2. Attach to these records the household weight, and geo-coded information (zone and coordinates) of the work and/or school location.

3. Attach areatype information based on the reported work location

4. Summarize the reported weighted average parking cost by zone and by areatype.

Table 2 shows the resulting observed parking cost.

Table 2: HIS-Based Parking Costs (daily, in cents in 1995 cost)		
Area type	Peak Parking Cost	Standard Error (Pct)
CBD (Areatype=1)	286	11%
Core Commercial (Areatype=2)	123	9%
Core Residential (Areatype=3)	80	25%

7.4 Conclusions

The observed data generally supports the 1995 modeled parking costs. Existing and future parking costs may be forecast by assuming no change in the real cost of parking, which has been observed in several other cities, due to the market-based nature of parking costs. For Honolulu, an effort was made to evaluate the change in retail parking costs over the past ten years to determine if the real cost of parking has changed, and what this might indicate for future year parking costs in the model. However, no data for this analysis was available.

Since the parking cost is an independent, exogenous input, changes in areatype do not affect the parking cost. Since it appears that the parking cost was closely tied to areatype in its development, it may be advisable to update the parking cost as densities and therefore areatypes change in the future.

Note that outside of these three areatypes, parking is free in the model. In some areas, such as Waikiki, parking may not be available at any price for some markets such as low-income workers. Therefore, a question has arisen regarding whether a parking shadow price mechanism or other type of drive-to-work penalty should be implemented in the model to accommodate this influence.

8.0 Preparation of Revised Calibration Target Values

The shares are calculated from the 1995 Home Interview Survey (HIS), and (for transit alternatives) from the 1991 DTS Transit Ridership Survey. Table 1 below shows the shares that currently exist in OMPO's Guide to Model Form Table 5.2-8. Table 2 shows the shares that will be used as a result of eliminating the geographical constant on Level 1 of the mode choice model. This table also eliminates the auto-ownership breakdown for drive path modes on Level 3 of the mode choice model. The auto-ownership market was removed from Level 3 for drive path modes since the shares by auto-ownership are identical for every trip purpose except Home-Based Work which was only different by about 3% (Table 1). However, in subsequent model calibration work, the auto ownership stratification of drive-access paths was restored.

Note: Table 2 is *not* a collapsed version of Table 1 but instead a new analysis of the survey data. However the journey to work (HBNW, WB, NB), journey at work, and non-work related purposes' *park and ride / kiss and ride shares* are the collapsed version of Table 1's respective values. Also I was not able to replicate Table 1's values with the survey data.

Table 1. "Table 5.2-8 Observed Shares Used to Calibrate Constants in the Mode Choice Model"

Purpose >	Journey To/From Work (JTW)				Journey At Work (JAW)		Non-Work Related (NWR)				
Share \/	HBW	HBNW	WB	NB	WB	NB	HBK12	HBCol	HBShp	HBOth	NHB
Level 1- Mode											
S0cbdHwy	0.13	0.07	--	--	--	--	0.98	0.01	0.01	0.06	--
S0cbdTrn	0.56	0.62	--	--	--	--	0.01	0.45	0.62	0.45	--
S0cbdAux	0.31	0.31	--	--	--	--	0.01	0.54	0.37	0.49	--
S0othHwy	0.05	0.16	--	--	--	--	0.01	0.10	0.11	0.21	--
S0othTrn	0.68	0.24	--	--	--	--	0.37	0.10	0.34	0.29	--
S0othAux	0.27	0.60	--	--	--	--	0.62	0.80	0.55	0.50	--
S0elsHwy	0.21	0.24	--	--	--	--	0.08	0.01	0.55	0.20	--
S0elsTrn	0.66	0.16	--	--	--	--	0.06	0.29	0.08	0.28	--
S0elsAux	0.13	0.61	--	--	--	--	0.86	0.70	0.37	0.52	--
S1cbdHwy	0.49	0.73	0.72	0.78	0.27	0.15	0.24	0.22	0.72	0.67	0.59
S1cbdTrn	0.40	0.15	0.10	0.08	0.03	0.01	0.01	0.77	0.09	0.07	0.16
S1cbdAux	0.11	0.11	0.18	0.15	0.71	0.84	0.75	0.01	0.18	0.25	0.26
S1othHwy	0.68	0.90	0.85	0.87	0.70	0.91	0.38	0.98	0.93	0.87	0.81
S1othTrn	0.16	0.04	0.05	0.05	0.02	0.01	0.18	0.01	0.01	0.05	0.05
S1othAux	0.16	0.06	0.10	0.09	0.27	0.08	0.44	0.01	0.06	0.07	0.14
S1elsHwy	0.80	0.96	0.95	0.97	0.89	0.95	0.42	0.65	0.86	0.84	0.90
S1elsTrn	0.08	0.01	0.01	0.01	0.01	0.01	0.13	0.22	0.04	0.03	0.02
S1elsAux	0.12	0.03	0.04	0.02	0.11	0.04	0.45	0.13	0.10	0.13	0.08
S2cbdHwy	0.77	0.97	--	--	--	--	0.90	0.68	0.91	0.90	--
S2cbdTrn	0.22	0.03	--	--	--	--	0.09	0.31	0.08	0.03	--
S2cbdAux	0.02	0.01	--	--	--	--	0.01	0.01	0.01	0.07	--
S2othHwy	0.88	0.97	--	--	--	--	0.93	0.48	0.88	0.89	--
S2othTrn	0.09	0.02	--	--	--	--	0.04	0.52	0.05	0.04	--
S2othAux	0.03	0.01	--	--	--	--	0.03	0.01	0.07	0.07	--
S2elsHwy	0.92	0.98	--	--	--	--	0.74	0.86	0.98	0.92	--
S2elsTrn	0.05	0.00	--	--	--	--	0.07	0.04	0.00	0.01	--
S2elsAux	0.04	0.02	--	--	--	--	0.19	0.11	0.01	0.07	--
Level 2- Highway Shared Ride											
S1o1	0.66	0.39	0.74	0.37	0.74	0.58	0.01	0.64	0.31	0.33	0.25
S1sr	0.34	0.61	0.26	0.64	0.26	0.42	0.99	0.36	0.70	0.67	0.75
S2o1	0.81	0.42	--	--	--	--	0.06	0.82	0.38	0.34	--
S2sr	0.19	0.58	--	--	--	--	0.94	0.19	0.62	0.67	--
Level 3- Highway Shared Ride Occupancy											
Socc2	0.81	0.62	0.79	0.68	0.72	0.80	0.38	0.77	0.58	0.55	0.52
Socc3	0.19	0.38	0.21	0.32	0.28	0.20	0.62	0.23	0.43	0.45	0.48
Level 2- Transit Access											
S0wacc	0.99	0.99	--	--	--	--	0.93	0.99	0.99	0.99	--
S0dacc	0.01	0.01	--	--	--	--	0.07	0.01	0.01	0.01	--
S1wacc	0.96	0.95	0.82	0.99	0.92	0.99	1.00	0.99	0.98	0.98	0.97
S1dacc	0.05	0.05	0.18	0.01	0.08	0.01	0.00	0.01	0.02	0.02	0.03
S2wacc	0.85	0.99	--	--	--	--	0.85	0.96	0.91	0.97	--
S2dacc	0.15	0.01	--	--	--	--	0.16	0.04	0.10	0.03	--
Level 3- Transit Walk Path											
Sngdwy	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Sgdwy	--	--	--	--	--	--	--	--	--	--	--
Sprem	--	--	--	--	--	--	--	--	--	--	--
Level 3- Transit Drive Path											
S1Pnr	0.38	0.30	0.19	0.19	0.19	0.19	0.30	0.30	0.30	0.30	0.19
S1Knr	0.62	0.70	0.81	0.81	0.81	0.81	0.70	0.70	0.70	0.70	0.81
S2Pnr	0.35	0.30	--	--	--	--	0.30	0.30	0.30	0.30	--
S2Knr	0.65	0.70	--	--	--	--	0.70	0.70	0.70	0.70	--
Level 2- Auxiliary Path											
Sauxw	0.79	0.92	0.94	0.99	0.96	0.99	0.93	0.63	0.92	0.91	0.95
Sauxb	0.21	0.08	0.06	0.01	0.04	0.01	0.07	0.37	0.08	0.09	0.05

Notes: 1) Purposes not based at home are not stratified by vehicle ownership—S1 shares apply across all vehicle-ownership strata. 2) "-- "indicates cell not applicable.

Table 2. Revised Observed Shares to Calibrate Mode Choice Model

Purpose >	Journey To/From Work (JTW)				Journey At Work (JAW)		Non-Work Related (NWR)				
Share \/	HBW	HBNW	WB	NB	WB	NB	HBK12	HBCol	HBShp	HBOth	NHB
Auto-Ownership/Level 1 Mode											
S0Hwy	0.14	0.14					0.05	-	0.20	0.15	
S0Trn	0.65	0.42					0.20	0.73	0.37	0.38	
S0Aux	0.22	0.45					0.75	0.27	0.43	0.47	
S1Hwy	0.67	0.91	0.86	0.93	0.72	0.81	0.53	0.59	0.84	0.81	0.85
S1Trn	0.21	0.05	0.06	0.03	0.03	-	0.11	0.30	0.06	0.06	0.06
S1Aux	0.12	0.04	0.07	0.04	0.26	0.19	0.36	0.10	0.10	0.13	0.10
S2Hwy	0.89	0.97					0.73	0.75	0.96	0.90	
S2Trn	0.08	0.01					0.10	0.16	0.02	0.03	
S2Aux	0.03	0.02					0.17	0.09	0.02	0.07	
Atype/Level 1 Mode											
CBDHwy	0.54	0.71					0.19	0.12	0.29	0.70	
CBDTrn	0.38	0.21					0.60	0.78	0.49	0.19	
CBDAux	0.08	0.08					0.20	0.10	0.23	0.11	
OthHwy	0.66	0.83	0.87	0.92	0.72	0.81	0.57	0.37	0.59	0.72	0.85
OthTrn	0.26	0.10	0.06	0.04	0.03	0.00	0.25	0.58	0.21	0.12	0.06
OthAux	0.08	0.07	0.07	0.04	0.26	0.19	0.18	0.05	0.19	0.16	0.10
ElsHwy	0.87	0.96					0.64	0.67	0.94	0.86	
ElsTrn	0.07	0.01					0.09	0.20	0.02	0.04	
ElsAux	0.06	0.03					0.27	0.12	0.04	0.10	
Level 2- Highway Shared Ride											
S1o1	0.66	0.39	0.74	0.37	0.74	0.58	0.01	0.64	0.31	0.33	0.25
S1sr	0.34	0.61	0.26	0.64	0.26	0.42	0.99	0.36	0.70	0.67	0.75
S2o1	0.81	0.42	--	--	--	--	0.06	0.82	0.38	0.34	--
S2sr	0.19	0.58	--	--	--	--	0.94	0.19	0.62	0.67	--
Level 3- Highway Shared Ride Occupancy											
Socc2	0.81	0.62	0.79	0.68	0.72	0.80	0.38	0.77	0.58	0.55	0.52
Socc3	0.19	0.38	0.21	0.32	0.28	0.20	0.62	0.23	0.43	0.45	0.48
Level 2- Transit Access											
S0wacc	0.99	0.99	--	--	--	--	0.93	0.99	0.99	0.99	--
S0dacc	0.01	0.01	--	--	--	--	0.07	0.01	0.01	0.01	--
S1wacc	0.96	0.95	0.82	0.99	0.92	0.99	1.00	0.99	0.98	0.98	0.97
S1dacc	0.05	0.05	0.18	0.01	0.08	0.01	0.00	0.01	0.02	0.02	0.03
S2wacc	0.85	0.99	--	--	--	--	0.85	0.96	0.91	0.97	--
S2dacc	0.15	0.01	--	--	--	--	0.16	0.04	0.10	0.03	--
Level 3 Mode – Drive Access											
PNR	0.34	0.30	0.19	0.19	0.19	0.19	0.30	0.30	0.30	0.30	0.19
KNR	0.66	0.70	0.81	0.81	0.81	0.81	0.70	0.70	0.70	0.70	0.81
Level 2- Auxiliary Path											
Sauxw	0.79	0.92	0.94	0.99	0.96	0.99	0.93	0.63	0.92	0.91	0.95
Sauxb	0.21	0.08	0.06	0.01	0.04	0.01	0.07	0.37	0.08	0.09	0.05

Notes: 1) Purposes not based at home are not stratified by vehicle ownership—S1 shares apply across all vehicle-ownership strata. 2) "-- "indicates cell not applicable.

Notice in Table 2 that the Level 1 mode is stratified by area type only. This is here in case there is a need to stratify trips going to certain areas like CBD, or Waikiki.

Tables 1 and 2's Key

S0, S1, S2 = Shares for Households with 0 cars, 1 car, and 2 car respectively

CBD = Attraction End of Trip is in Central Business District

OTH = Attraction End of Trip is in Core Commercial and Core Residential area.

ELS = Attraction End of Trip is in Urban, Suburban, or Rural area.

HWY = Mode is Auto in Level 1 of the Mode Choice Model.

TRN = Mode is Transit in Level 1 of the Mode Choice Model.

AUX = Mode is Non-motorized in Level 1 of the Mode choice Model.

O1 = Mode is Drive alone in Level 2 of the Mode Choice Model.

SR = Mode is Shared Ride in Level 2 of the Mode Choice Model.

OCC2 = Mode is Shared Ride 2-Persons in Level 3 of the Mode Choice Model.

OCC3 = Mode is Shared Ride 3 or more persons in Level 3 of the Mode Choice Model

WACC = Mode is Walk Access to Transit in Level 2 of the Mode Choice Model.

DACC = Mode is Drive Access to Transit in Level 2 of the Mode Choice Model.

NGDWY = Mode is walk access to Local Bus in Level 3 of the Mode Choice Model.

GDWY = Mode is walk access to guideway in Level 3 of the Mode Choice Model.

PREM = Mode is walk access to premium bus in Level 3 of the Mode Choice Model.

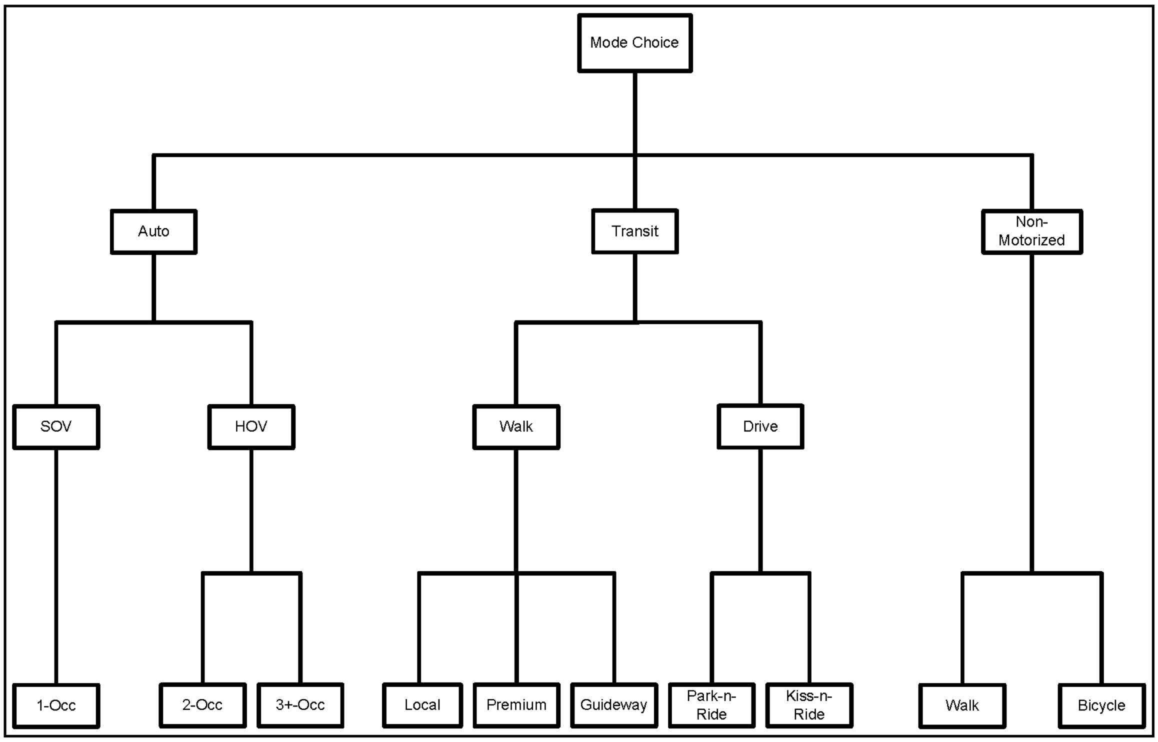
PNR = Mode is Park and Ride in Level 3 of the Mode Choice Model.

KNR = Mode is Kiss and Ride in Level 3 of the Mode Choice Model.

AUXW = Mode is Walk in Level 2 of the Mode Choice Model.

AUXB = Mode is Bike in Level 2 of the Mode Choice Model.

Figure 3. Structure of the Nested Logit Mode Choice Model



9.0 Re-Calibrate Mode Choice Model and Make Model Structural Changes

9.1 Introduction and Background

The current OMPO mode choice model was developed based on data from the 1995 Home Interview Survey conducted on the island of O'ahu and a 1991 Transit On-Board Survey, which was used to generate target values for model calibration of mode-specific constants. Calibration of these constants is an iterative process that estimates the values of the constants necessary to match observed mode shares on O'ahu. The models produced by this combination of borrowing and calibration combine the wealth of experience that has been accumulated across the United States together with the O'ahu-specific travel information in the two surveys to produce models that realistically represent current travel patterns on the island.

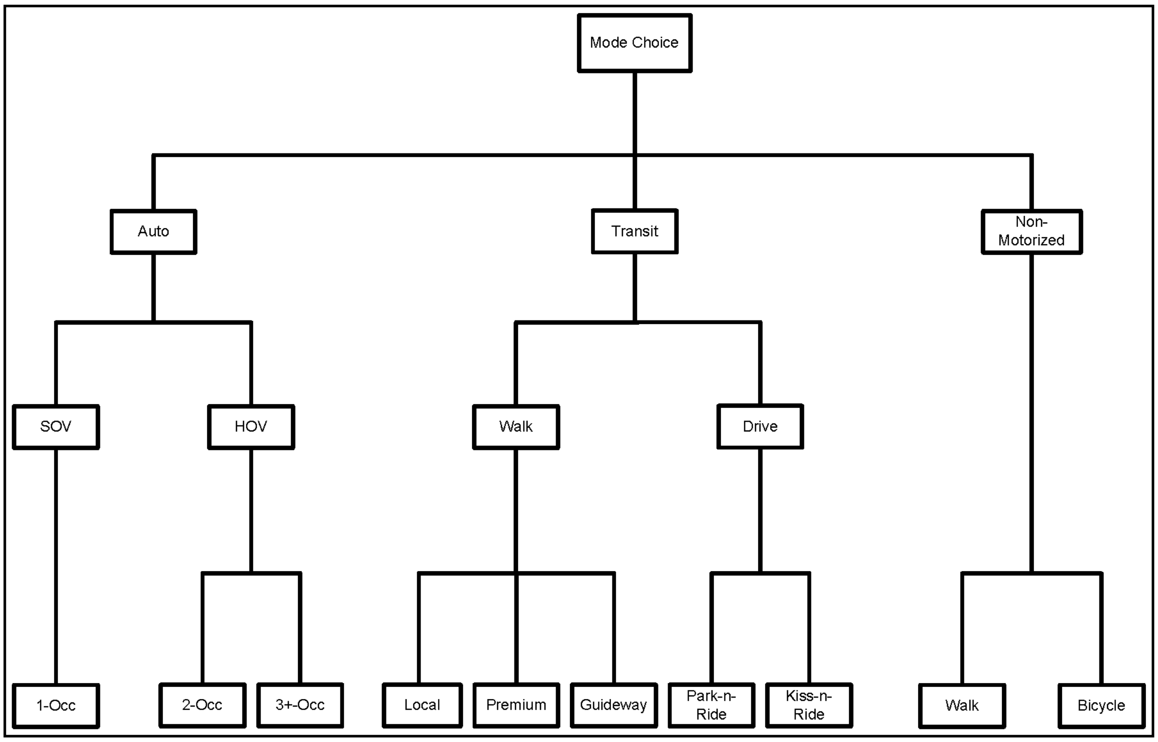
The OMPO mode choice application program has an auto-calibration capability, so that it can perform automatically the iterative calibration of constants based on user-provided observed shares for each travel mode, socioeconomic stratum, and geographic subarea.

This memo describes the recent work to update the parameter specification (coefficients) and model structure. The results of the updated model calibration, in terms of the values of mode-specific constants, will also be presented.

9.2 Current Model Structure

Figure 1 shows the model nesting structure. The model has a traditional nesting structure, with transit access nested below the overall transit mode. Line-haul modes of Local, Premium (i.e., express) and guideway, if available are nested below walk access while park-and-ride and kiss-and-ride modes, regardless of line-haul mode are nested below drive-access. A recent addition to this structure, not shown, is the addition of toll and non-toll choices below the SOV, 2 occupant and 3+occupant auto modes.

Figure 1: OMPO Mode Choice Model Nesting Structure



9.3 Coefficients

Table 1 shows the original and proposed model coefficient for the OMPO mode choice model.

Table 1: Original and Proposed Model Coefficients

Existing

Purpose	Journey To/From Work (JTW)				Journey At Work (JAW)		Non-Work Related (NWR)				
Coefficient	HBW	HBNW	WB	NB	WB	NB	HBK12	HBCol	HBShp	HBOth	NHB
Generic											
In-vehicle Time	-0.0185	-0.0185	-0.0185	-0.0185	-0.0181	-0.0181	-0.0110	-0.0185	-0.0181	-0.0181	-0.0181
Walk time	-0.0370	-0.0370	-0.0370	-0.0370	-0.0362	-0.0362	-0.0220	-0.0370	-0.0362	-0.0362	-0.0362
Wait time	-0.0318	-0.0318	-0.0318	-0.0318	-0.0362	-0.0362	-0.0185	-0.0318	-0.0362	-0.0362	-0.0362
Cost	-0.0031	-0.0031	-0.0031	-0.0031	-0.0449	-0.0449	-0.0040	-0.0031	-0.0449	-0.0449	-0.0449
Transfers	-0.0918	-0.0918	-0.0918	-0.0918	-0.2172	-0.2172	-0.1110	-0.0918	-0.2172	-0.2172	-0.2172
Nesting Coefficient											
Access	0.447	0.447	0.447	0.447	0.447	0.447	0.447	0.447	0.447	0.447	0.447
Path	0.447	0.447	0.447	0.447	0.447	0.447	0.447	0.447	0.447	0.447	0.447
Lot	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Auto	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85
Occupancy	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
Auxiliary	1	1	1	1	1	1	1	1	1	1	1

Table 1(continued): Original and Proposed Model Coefficients

	Purpose	Journey To/From Work (JTW)				Journey At Work (JAW)		Non-Work Related (NWR)				
	Coefficient	HBW	HBNW	WB	NB	WB	NB	HBK12	HBCol	HBShp	HBOth	NHB
Variable Relationships	**Generic**											
	In-vehicle Time	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
	Walk time	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000
	Wait time	3.4378	3.4378	3.4378	3.4378	4.0000	4.0000	3.3636	3.4378	4.0000	4.0000	4.0000
	Cost	0.1676	0.1676	0.1676	0.1676	2.4807	2.4807	0.3636	0.1676	2.4807	2.4807	2.4807
	Transfers	4.9622	4.9622	4.9622	4.9622	12.0000	12.0000	10.0909	4.9622	12.0000	12.0000	12.0000
Proposed Values	**Generic**											
	In-vehicle Time	-0.0250	-0.0250	-0.0250	-0.0250	-0.0200	-0.0200	-0.0100	-0.0250	-0.0100	-0.0100	-0.0100
	Walk time	-0.0500	-0.0500	-0.0500	-0.0500	-0.0400	-0.0400	-0.0200	-0.0500	-0.0200	-0.0200	-0.0200
	1st Wait <5	-0.0500	-0.0500	-0.0500	-0.0500	-0.0400	-0.0400	-0.0200	-0.0500	-0.0200	-0.0200	-0.0200
	1st Wait >5	-0.0250	-0.0250	-0.0250	-0.0250	-0.0200	-0.0200	-0.0100	-0.0250	-0.0100	-0.0100	-0.0100
	Transfer Wait	-0.0500	-0.0500	-0.0500	-0.0500	-0.0400	-0.0400	-0.0200	-0.0500	-0.0200	-0.0200	-0.0200
	Cost	-0.0042	-0.0042	-0.0042	-0.0042	-0.0050	-0.0050	-0.0084	-0.0042	-0.0084	-0.0084	-0.0084
	Transfers	-0.1241	-0.1241	-0.1241	-0.1241	-0.2400	-0.2400	-0.1200	-0.1241	-0.1200	-0.1200	-0.1200
	Nesting Coefficient											
	Access	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	Path	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	Lot	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	Auto	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	Occupancy	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	Auxiliary	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	Value Of Time	\$3.58	\$3.58	\$3.58	\$3.58	\$0.24	\$0.24	\$1.65	\$3.58	\$0.24	\$0.24	\$0.24

Several changes have been made to rationalize the coefficients, in light of current "best practices" as they relate to these values.

- The in-vehicle time for the JTW purposes (and HB College) is low at -0.0185, and we have suggested an asserted value of -0.0250. Similarly, the remaining non-work purposes (except for K12) are adjusted from -0.0181 to -0.02 for JAW and -0.0100 for non-work-related purposes. Adjustments were also made to reflect a 2:1 ratio for walk and initial wait time relative to IVT for all purposes where previously the wait time was 3-4 times the in-vehicle time. The cost coefficient for JTW and HB College was set to reflect a $3.58 average hourly value of time. The non-work related cost coefficient was set at twice the JTW cost coefficient, and the at-work cost coefficient was set at 1.2 times the JTW coefficient. This leads to a value of time for at-work and non-work related purposes of $0.24.

- Transit time penalties, originally at the equivalent of 6 wait time minutes, were adjusted down for JTW and HB College purposes to 2.48 minutes.

- Wait time was originally not stratified, but we are suggesting that a separate short initial wait coefficient equivalent to 2 times the in-vehicle time coefficient should be used for the first 5 minutes of the initial wait time and all subsequent transfer wait times. A lower value, equal to the in-vehicle time coefficient, should be used for the portion of the initial wait time longer than 5 minutes.

- The original nesting coefficients were constant across purposes, but varied considerably by level and nest group. Notably, the non-motorized nest coefficient was 1.0, meaning that the walk and bike modes effectively operated at the top level of the nest. In the interests of simplicity, and to rationalize these values, we have suggested using a single nesting coefficient value of 0.5 for all purposes and nests.

9.4 Model Structural Changes

Several changes have been made to the mode choice model to reflect recent best practices. These are listed and discussed below:

- The removal of requirement for non-zero attraction end parking cost for park and ride. Previously the model would not allow consideration of park and ride use if the parking cost at the destination end was zero. This has been removed to allow any destination.

- The removal of maximum drive time ratio threshold for park-and-ride access. Previously, the drive time for PNR could not exceed 1/3 of the transit in-vehicle time, otherwise, the PNR mode was not allowed. Now, a function is used to penalize longer drive access trips, with no penalty if the ratio of drive time to total ivt is less the ¼. Beyond this, there is a linear penalty added, with a maximum (drive time/total ivt = 1.0) of about 27 minutes. In addition, the minimum drive time threshold was removed. Note that a restriction preventing PNR transit trips with a production end in the CBD remains.

- Allowing additional PNR trips to informal park and ride locations. Originally, PNR could occur only through formal PNR lots. The model was modified to allow PNR to occur at any site, using the KNR utility and adding a fixed constant. When this constant is very small, (-10.0) then no informal lots are allowed. However, when the value is about -0.5 to -1.0, additional PNR opportunities are allowed. This feature was found to be very useful in creating a sufficient market to allow proper calibration of PNR/KNR constants. It also reflects the fact that observed data indicates pnr trips are occurring at informal lot locations.

- Non-Motorized travel is now allowed for intra-zonal interchanges. Previously, the auxiliary mode (i.e., non-motorized) skim generation did not calculate intra-zonal times, leaving them at 0. The mode choice model recognizes this as an unconnected interchange, and no non-motorized trips are estimated. As a corollary to this change, the auxiliary skims were also limited to 30 min for both walk (at 3 mph) and bike (at 7 mph). All valid non-motorized interchanges are now included in the skims, though the mode choice model can be used to limit the maximum time. Non-motorized trips longer than 30 minutes are, however a very small share of total non-motorized trips. The intrazonal restriction is much more significant, especially for K12, College, HBO and Shopping trips. The greater market for non-motorized trips permits much more reasonable constants for bike and non-motorized travel in the new calibrated model.

- The geography stratification has been modified so that the user may exclude its use through keyword specification. This is the default condition and has been used for the initial model re-calibration. In addition, if the geography stratification is used, it will be applied only at the top (auto, transit, non-motorized) level through separate constants stratified by area and mode, but not jointly stratified (as before) with auto ownership. This will allow us to directly observe the nature of the geography- based constants, if they are employed.

- Though not affecting the model calculations, two summary reports have been added to the model report file. Report 1 gives the market, trips and market share for each mode by auto ownership. This is a very useful report for evaluating the adequacy of the market for a particular mode. Report 2 gives the same market share information by distance for each transit mode.

- The self-calibration module was modified to be compatible with the new constants, and user options allow for “freezing” of turning off the calibration of geography constants, KNR and drive-access constants.

9.5 Model Calibration

With the exception of the long initial weight coefficient, these changes were used for a new model calibration for each of the 11 trip purposes. Stratifying the initial wait time will require a modification to the transit skim generation, and other changes to the mode choice model to ensure backward compatibility. The transit skims that were used were based on the new conical delay functions and the updated transit target shares were used as well.

Table 2 shows the original calibrated constants, and Table 3 shows the new constants, after calibration. As Table 2 shows there were some extremely large positive and negative constants in the model, which worked to overwhelm any level of service differences.

For HBW, K12 and, to some degree, for college and shopping purposes, the 2+ auto drive-access constant is very large while the 2+ Auto KNR constant is equally negative. The source of these large constants is a lack of market share for pnr trips. This forces the KNR constant to become very small, as the PNR mode seeks to capture 100% of the available trips. The drive-access constant becomes large in an effort to capture more overall drive access trips for PNR. In the new model re-calibration, the KPKNR constant is used to allow some KNR markets to be used for PNR. With a larger market, this allows much more moderate constants for both drive access and KNR.

Another instance of extreme constants in the previous model calibration occurs for constants related not non-motorized and bike shares. This occurs for JTW-NW, and all NWK except for NHB. We believe that these very high positive constants are a result of insufficient non-motorized markets. The new model addresses this by allowing intra-zonal non-motorized times, and by allowing a relaxation of the 30 min maximum non-motorized time. The presence of the intra-zonal times is the most important change. The new calibrated non-motorized constants are, in some cases still somewhat high for 0-auto households, but are very reasonable for other auto ownership levels.

The relationships between the constants are logical. Both non-motorized and transit constants show decreasing attractiveness with increasing auto ownership, except for College trips where non-motorized travel is slightly more favored with 2 or more auto households than with 1 auto households. Drive access to transit generally is more attractive for households with more autos, except for JTW-NW where households with 2+ autos are much less likely to use drive access, maybe because with 2 or more autos in a household, all workers are likely to have a car, and this makes it easier to drive directly to an intermediate stop to or from work. The other exception is for K12 school trips, for which 1 auto households are much less likely to drive access than 0 auto households. This may be related to the unique nature of K12 school trips, which probably have very little PNR activity at all. The KNR constants are very similar between 1 and 2+ auto ownership groups, with the exception of Shopping trips, for which owning 2+ autos in a household makes KNR much less attractive. This is probably related to the need to haul shopping items in a car, and not be relying on someone else for a pickup on the return trip.

The 3+ occupancy constant is consistently negative across all purposes, as was the case in the original calibration. The shared ride constants all show less attractiveness to share a ride with increasing auto ownership levels. The shared ride constants are negative, except for K12, Shopping, NWK-HO, and NWK-NN. This is consistent with the original calibration pattern.

The premium (i.e., express) transit constants are negative, except for the JAW purposes, for which they are slightly positive. All were negative in the original calibration. The high frequency and good access to local service may present an attractive alternative to express service in many areas.

The bike constant remains negative for all purposes, as walk dominates the non-motorized mode.

Table 2: Original Mode Choice Model Constants

Purpose >	Journey To/From Work (JTW)				Journey At Work (JAW)		Non-Work Related (NWR)				
Constant V	HBW	HBNW	WB	NB	WB	NB	HBK12	HBCol	HBShp	HBOth	NHB
Level 1- Mode											
K0cbdTrn	1.305	2.716	0.25	0.25	0.25	0.25	-3.74	29.786	67.725	2.483	--
K0cbdAux	5.346	16.346	--	--	--	--	-3.397	87.097	67.888	17.43	--
K0othTrn	2.716	1.351	0.25	0.25	0.25	0.25	62.878	1.062	2.913	2.144	--
K0othAux	3.19	23.318	--	--	--	--	77.959	77.145	3.567	9.498	--
K0elsTrn	3.692	1.407	0.25	0.25	0.25	0.25	3.003	6.505	0.962	4.493	--
K0elsAux	9.09	46.961	--	--	--	--	66.297	66.229	3.614	26.541	--
K1cbdTrn	0.149	-0.756	-1.873	-1.538	-2.204	-2.542	1.064	1.728	-1.185	-1.397	-0.479
K1cbdAux	3.304	1.187	0.337	-0.196	4.84	77.065	33.335	-0.589	1.748	14.462	-0.383
K1othTrn	-0.801	-2.046	-2.3	-1.832	-2.354	-3.344	3.751	-3.868	-2.444	-0.878	-0.688
K1othAux	0.519	-0.762	-0.446	-0.505	0.008	-1.769	7.3	-1.717	-1.007	-0.333	-0.145
K1elsTrn	-0.925	-2.439	-3.253	-3.266	-3.024	-1.946	4.046	0.508	0.115	0.07	-0.45
K1elsAux	4.937	-0.39	-0.069	-0.647	1.272	-0.631	32.59	56.469	1.906	6.049	1.148
K2cbdTrn	-1.063	-2.75	0.25	0.25	0.25	0.25	0.038	-0.523	-1.784	-2.528	--
K2cbdAux	0.723	-1.872	--	--	--	--	-0.895	-0.623	-2.648	11.137	--
K2othTrn	-1.699	-2.689	0.25	0.25	0.25	0.25	-0.473	0.771	-0.944	-0.893	--
K2othAux	-0.516	-2.355	--	--	--	--	-0.008	0.443	0.055	0.498	--
K2elsTrn	-1.88	-3.656	0.25	0.25	0.25	0.25	0.827	-1.712	-2.954	-1.121	--
K2elsAux	0.965	-0.77	--	--	--	--	4.297	57.213	-0.879	2.215	--
Level 2- Highway Shared Ride											
K1sr	-0.924	-0.05	-1.23	0.098	-1.084	-0.416	3.488	-0.914	0.347	0.228	0.529
K2sr	-1.606	-0.183	--	--	--	--	1.589	-1.692	0.056	0.197	--
Level 3- Highway Shared Ride Occupancy											
Kocc3	-1.214	-0.449	-1.067	-0.616	-0.694	-1.026	0.325	-1.042	-0.227	-0.138	-0.057
Level 2- Transit Access											
K0dacc	-1.287	-1.249	-3.05	-3.05	-4.05	-2.05	-0.588	-1.793	-1.28	-1.841	--
K1dacc	3.919	2.155	27.263	1.483	5.204	1.675	-1.253	-0.298	0.39	0.539	3.366
K2dacc	17.187	-0.312	-1.3	-1.3	-2.3	-0.3	26.932	5.178	3.924	1.607	--
Level 3- Transit Walk Path											
Kgdwy	--	--	--	--	--	--	--	--	--	--	--
Kprem	-0.487	-1.163	-0.954	-0.929	-0.527	-0.595	-1.129	-1.505	-0.762	-1.134	-0.79
Level 3- Transit Drive Path											
K1Knr	-4.757	-2.529	-26.803	-2.145	-3.674	-1.662	-1.002	-1.531	-1.252	-1.595	-3.433
K2Knr	-17.614	-1.76	-0.15	0.75	0.75	-0.25	-27.235	-6.325	-3.595	-2.452	--
Level 2- Auxiliary Path											
Kauxb	-5.435	-44.147	-3.93	-5.539	-6.704	-80.107	-29.098	-58.261	-4.203	-15.955	-3.988

Table 3: New Calibrated Constants, with Model Structural Changes

Description	Keyword	JTW				JAW		NWK				
		HW	NW	WB	WN	AW	AN	NK	NC	NS	NO	NN
3+Occupancy	Kocc3	-1.532	-0.676	-1.287	-0.697	-0.462	-0.684	-0.053	-1.440	-0.151	-0.092	-0.038
1-Auto Shared Ride	K1sr	-0.921	-0.200	-1.104	-0.102	-0.596	-0.216	1.905	-0.993	0.274	0.209	0.393
2+ Auto Shared Ride	K2sr	-1.540	-0.314					0.841	-1.655	0.103	0.192	
Fixed Guideway	Kgdwy	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Premium Walk Access Transit	Kprem	-0.660	-1.515	-1.315	-1.061	0.092	0.295	-1.256	-2.098	-0.537	-0.665	-0.323
1 Auto KNR	K1Knr	-0.834	-0.733	-0.624	-2.238	-0.593	-0.104	-0.700	-0.626	-1.972	-0.732	-0.614
2+ Auto KNR	K2Knr	-0.826	-0.713					-0.780	-0.736	-3.711	-0.755	
KNR constant for PNR	KPKnr	-1.000	-1.000	-1.000	-10.000	-1.000	-0.500	-1.000	-1.000	-10.000	-1.000	-1.000
0-Auto Drive Access (all KNR)	K0dacc	-1.482	-1.607	0.643	0.840	1.902	0.737	-0.811	-1.893	-1.421	-1.927	0.084
1 Auto Drive Access	K1dacc	-0.329	-0.158					-2.046	-1.659	0.886	-0.494	
2+ Auto Drive Access	K2dacc	0.194	-1.284					0.403	-0.839	3.540	-0.293	
Bike share of NM	Kauxb	-3.417	-10.324	-3.444	-4.784	-3.862	-4.494	-5.197	-1.986	-2.762	-2.340	-2.801
0 Auto Transit	K0Trn	2.651	2.196					1.984	5.420	2.452	1.970	
1 Auto Transit	K1Trn	-1.254	-2.937	-3.603	-3.286	-3.180	-3.477	0.972	-0.482	-0.683	-1.319	-0.607
2+ Auto Transit	K2Trn	-3.083	-4.001					-0.493	-1.764	-1.778	-2.316	
0 Auto Non-Motorized	K0Aux	4.302	11.262					8.992	5.336	1.829	2.944	
1 Auto Non-Motorized	K1Aux	1.064	-1.319	-1.022	-1.523	0.936	-0.076	3.963	0.282	0.113	-0.114	-0.505
2+ Auto Non-Motorized	K2Aux	-0.617	-1.534					1.030	0.522	-1.531	-0.542	

9.6 Preliminary Validation

Mode choice validation tests have begun, using base year comparisons to home interview and transit on-board data. Preliminary results indicate that HBW transit trips to the CBD are reasonable in terms of the share of total transit trips, with a 1991 observed 32 percent vs. an estimated 29% of transit work trips being destined for the CBD. Another area of interest is Waikīkī, where there is a large employment concentration for whom transit may be an attractive option, based on auto availability, cost and parking availability. The recent on-board survey may also add to our understanding of this transit market.

Early indications also point to more evaluation of transit market share and mode share by distance. The model appears to overestimate these shares at longer distances, and underestimates shares at shorter trip lengths. More investigation is necessary fully evaluate this effect.

Appendix C: Socioeconomic Data by TAZ

YEAR 2030 ORTP DATA BY TAZ

TAZ	POP	GQ	HR	RC	HU	H1	H2	H3	H4	H5	J1	J2	J3	J4	J5	J6	J7	J8	J9	J10	DPSA	NB	MIL
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	401	1	0
2	2329	14	0	0	854	156	282	162	136	105	0	0	0	0	21	11	10	53	42	8	401	1	0
3	498	0	0	0	191	20	76	43	32	13	0	0	0	0	5	7	6	12	1	1	401	1	0
4	1213	0	0	0	390	23	115	102	83	59	0	0	0	0	29	8	12	45	39	2	401	1	0
5	1008	5	0	0	412	118	139	53	38	54	0	2	0	0	0	0	0	51	0	14	401	1	0
6	1963	0	0	0	610	30	179	152	146	96	0	3	0	0	0	5	35	36	5	7	401	1	0
7	2117	0	0	0	663	42	223	155	123	110	0	5	0	0	0	0	0	123	0	6	401	1	0
8	444	0	0	0	199	36	70	41	33	3	0	0	0	0	1	0	0	14	0	8	401	1	0
9	960	0	0	0	307	18	107	77	52	52	0	2	0	6	28	6	7	77	33	2	401	1	0
10	989	0	0	0	319	29	103	74	61	48	0	1	0	9	16	7	1	80	4	3	401	1	0
11	2190	0	0	0	1030	218	407	159	121	40	0	0	0	1	1	0	0	12	0	30	401	1	0
12	239	0	0	0	79	9	21	22	13	14	0	5	0	27	137	34	83	293	410	5	401	1	0
13	1079	0	0	0	351	37	116	74	55	62	0	3	0	0	17	0	0	164	0	1	401	1	0
14	898	5	0	0	383	50	144	54	46	38	0	1	0	0	5	1	0	2	2	1	401	1	0
15	653	0	0	0	253	46	80	63	40	17	0	0	0	0	2	0	0	8	0	2	401	1	0
16	1332	0	0	0	536	81	208	128	70	33	0	0	0	0	1	0	0	5	0	6	401	1	0
17	349	0	0	0	118	9	42	37	12	16	0	0	0	0	0	0	0	4	0	0	401	1	0
18	927	0	0	0	310	23	106	64	69	39	0	0	0	0	1	0	0	4	0	1	401	1	0
19	656	0	0	0	273	36	100	63	41	14	0	0	0	0	1	0	0	4	0	0	401	1	0
20	5063	4	0	0	2601	592	1176	446	157	28	0	7	0	0	22	0	1	252	1	43	401	1	0
21	844	0	0	0	366	52	152	75	40	19	0	25	0	0	19	4	34	156	220	2	401	1	0
22	0	0	0	0	0	0	0	0	0	0	0	104	0	0	46	13	113	392	432	3	401	1	0
23	1448	0	0	0	545	66	204	109	73	67	0	0	0	0	1	0	1	4	0	2	401	1	0
24	979	0	0	0	326	23	109	70	65	48	0	18	0	12	99	45	89	259	29	5	401	1	0
25	1644	2	0	0	713	208	202	99	106	54	0	0	0	0	2	0	1	5	0	8	401	1	0
26	750	0	0	0	313	63	110	54	39	28	0	0	0	0	1	0	0	0	0	1	401	1	0
27	1022	55	0	0	347	70	93	73	52	46	0	1	0	0	2	0	1	27	0	1	402	2	0
28	448	6	0	0	201	36	81	35	15	15	0	2	0	0	3	0	0	94	0	1	402	2	0
29	2388	10	0	0	896	122	346	179	140	86	0	2	0	0	4	0	1	69	1	8	402	2	0
30	673	0	0	0	261	33	114	51	43	18	0	0	0	0	1	0	0	5	0	2	402	2	0
31	1179	19	0	0	405	59	129	87	72	52	0	5	0	0	15	67	25	238	93	4	402	2	0
32	1965	0	0	0	818	91	295	182	156	23	0	1	0	0	2	0	1	16	1	15	402	2	0
33	114	0	0	0	65	16	19	10	5	2	0	4	0	0	0	0	0	40	0	1	402	2	0
34	564	0	0	0	197	28	66	45	28	26	0	0	0	0	1	0	0	4	0	1	402	2	0
35	1218	0	0	0	456	81	171	73	61	60	0	1	0	0	1	0	1	16	0	4	402	2	0
36	1238	0	0	0	460	72	172	87	57	59	0	0	0	0	1	0	1	4	0	3	402	2	0
37	818	20	0	0	299	53	102	63	33	41	0	39	0	0	13	5	83	300	135	3	402	2	0
38	506	0	0	0	194	33	63	25	26	30	0	10	0	0	2	0	0	108	0	1	402	2	0
39	264	0	742	2	265	42	63	26	8	0	0	0	172	0	14	3	73	188	31	25	403	3	0
40	416	0	97	0	160	19	59	31	22	17	0	0	0	0	2	0	1	8	0	9	402	2	0
41	221	0	0	0	89	18	29	25	11	5	0	0	0	0	0	0	0	0	0	1	402	2	1
42	3206	0	0	0	1235	185	453	239	186	119	0	0	0	1	0	0	0	8	0	18	402	2	0
43	869	7	0	0	325	48	114	61	47	37	0	0	0	0	0	0	0	4	0	2	402	2	0
44	773	2	0	0	375	104	167	51	35	8	0	4	0	0	12	0	0	124	0	18	403	3	0
45	2415	0	0	0	894	117	337	190	135	92	0	0	0	0	8	5	38	11	21	5	403	3	0
46	1041	0	0	0	425	148	127	39	42	57	0	2	0	0	15	0	18	97	11	23	101	3	0
47	1110	0	0	0	519	149	167	98	52	22	4	41	0	0	15	11	54	517	100	10	101	3	0
48	1480	0	0	0	588	176	163	78	68	72	0	0	0	1	9	0	11	71	7	33	102	4	0
49	1803	0	0	0	690	164	204	130	87	85	0	0	0	0	31	46	74	285	162	14	102	4	0
50	600	5	0	0	220	60	57	25	31	35	0	31	0	0	15	5	3	194	19	6	102	4	0
51	140	0	0	0	85	40	11	6	6	5	4	10	0	13	64	174	174	559	469	15	102	4	0
52	817	2	0	0	332	95	95	58	33	36	0	6	0	5	42	75	80	456	355	11	102	4	0
53	950	14	0	0	369	101	112	50	42	49	0	9	0	6	49	80	92	660	329	9	103	4	0
54	1408	321	0	0	486	137	142	85	54	33	0	4	0	0	13	0	30	412	121	15	103	5	0
55	688	16	0	0	306	95	81	41	32	27	0	3	0	0	16	0	31	389	148	9	104	6	0
56	1800	0	0	0	728	199	218	101	76	90	0	4	0	0	17	0	18	272	23	19	104	6	0
57	1089	2	0	0	367	65	112	71	53	61	0	0	0	0	0	1	0	47	9	5	104	6	0
58	2046	9	0	0	762	207	199	123	98	108	0	0	0	1	0	19	0	83	43	16	104	6	0
59	4219	131	0	0	1694	493	506	260	186	172	0	0	0	14	24	26	0	505	40	49	102	4	0
60	3287	57	0	0	1166	268	311	197	151	184	0	0	0	2	30	17	0	185	29	51	104	6	0
61	881	0	0	0	314	73	86	56	47	45	0	0	0	1	6	0	0	74	3	16	104	6	0
62	1927	3	0	0	606	115	117	91	92	147	0	11	0	13	0	29	13	241	9	12	104	6	0
63	2176	3	0	0	687	101	181	142	107	141	0	37	0	6	0	0	9	227	40	31	104	6	0
64	3261	0	0	0	1287	366	384	207	151	146	0	0	0	1	34	0	39	222	37	30	103	5	0
65	2229	858	0	0	651	211	199	77	57	51	22	16	0	1	15	0	30	1008	81	40	105	7	0
66	2354	1787	0	0	238	64	71	45	26	17	60	217	0	0	218	22	94	9085	195	12	105	7	0
67	2027	18	0	0	767	191	212	126	96	102	0	53	0	1	106	27	172	761	541	48	105	7	0
68	3867	0	0	0	1499	414	442	245	181	180	0	0	0	1	24	0	36	150	12	31	105	7	0
69	3270	0	0	0	1226	314	347	205	156	165	0	12	0	31	34	52	36	363	80	33	105	7	0
70	1020	1	0	0	410	116	108	60	52	50	0	30	1	0	0	7	46	332	82	9	105	7	0

YEAR 2030 ORTP DATA BY TAZ

TAZ	POP	GQ	HR	RC	HU	H1	H2	H3	H4	H5	J1	J2	J3	J4	J5	J6	J7	J8	J9	J10	DPSA	NB	MIL
71	1066	4	2	0	419	111	125	79	45	44	0	12	2	1	0	2	24	140	5	14	105	7	0
72	1233	18	0	0	503	121	167	71	49	56	0	1	1	1	0	0	9	47	5	14	108	10	0
73	1059	30	0	0	442	141	112	65	54	42	0	6	1	0	0	0	5	89	3	12	105	7	0
74	1244	124	46	2	470	144	137	74	47	45	0	1	19	0	12	15	19	134	67	17	105	7	0
75	733	107	0	3	262	65	78	42	30	26	0	10	2	0	41	2	10	1121	58	7	105	7	0
76	2705	2	0	1	1404	526	459	179	95	57	0	1	1	0	8	0	3	183	3	26	105	7	0
77	258	0	0	0	92	15	27	14	21	12	0	0	0	0	1	0	1	31	1	1	105	7	0
78	308	0	0	1	129	42	35	17	10	17	0	3	1	0	14	0	3	406	3	2	105	7	0
79	124	0	0	0	58	17	17	11	7	2	0	1	0	0	5	0	1	165	30	1	105	7	0
80	906	0	0	0	348	82	108	65	39	43	0	0	0	0	8	3	9	56	36	4	103	5	0
81	794	0	0	0	297	67	90	50	39	38	0	0	0	0	7	0	7	41	5	5	102	4	0
82	520	15	0	0	178	44	46	31	33	22	0	0	0	0	4	0	4	42	3	6	102	4	0
83	1286	1	0	0	504	130	142	76	66	56	0	0	0	1	21	34	45	132	210	13	103	5	0
84	2166	8	0	0	820	199	223	140	97	119	16	0	0	0	13	17	14	139	65	19	103	5	0
85	462	0	0	0	170	37	50	25	25	26	0	0	0	0	0	0	0	30	1	5	102	4	0
86	1282	11	0	0	427	86	103	84	59	78	0	1	0	0	0	0	0	30	4	11	102	4	0
87	423	0	0	0	147	35	35	30	17	28	0	0	0	0	0	0	0	30	2	6	102	4	0
88	471	0	0	0	170	41	52	22	27	22	0	15	0	0	0	0	0	161	7	3	102	4	0
89	453	171	0	0	111	34	33	18	9	14	0	239	0	0	3	34	14	553	39	2	102	4	0
90	1200	14	0	0	481	131	141	82	54	52	0	21	0	0	8	0	7	74	5	19	102	4	0
91	165	0	0	0	62	22	13	8	12	7	0	33	0	0	1	0	1	100	1	3	102	4	0
92	462	0	0	0	162	33	43	39	21	20	0	0	0	0	2	0	2	28	1	3	102	4	0
93	952	0	0	0	350	76	104	57	45	54	0	4	0	0	5	0	4	36	3	12	102	4	0
94	730	0	0	0	277	82	74	39	31	42	0	20	0	0	10	0	10	338	6	13	102	4	0
95	1556	46	0	0	556	129	154	103	76	74	0	3	0	2	7	1	18	66	7	18	102	4	0
96	628	0	0	0	234	60	74	38	30	30	0	9	0	3	6	3	31	189	72	8	102	4	0
97	207	0	0	0	124	33	38	5	10	8	44	0	0	4	137	75	323	740	1705	11	101	3	0
98	352	0	0	0	127	17	35	25	24	13	0	0	0	0	2	0	2	47	2	2	101	3	0
99	632	0	0	0	252	58	76	41	25	31	0	0	0	1	16	6	35	139	14	10	101	3	0
100	1058	0	0	0	447	125	102	74	45	53	0	0	0	1	11	0	12	53	8	19	101	3	0
101	916	0	0	0	393	93	102	55	44	46	0	0	0	1	15	11	34	127	15	16	101	3	0
102	1392	6	0	0	584	117	187	90	66	62	0	265	0	0	66	9	17	1079	35	28	101	3	2
103	1	0	0	0	1	1	0	0	0	0	0	56	0	0	36	8	4	137	29	0	102	4	0
104	49	0	0	0	18	37	0	0	0	2	262	23	0	1	28	0	17	130	11	14	103	5	2
105	987	0	50	65	993	353	188	58	17	3	11	65	135	1	8	0	37	364	6	17	103	5	0
106	0	0	115	10	1	0	0	0	0	0	0	11	48	5	9	14	22	48	163	7	103	5	0
107	1136	0	13	0	826	319	194	89	25	11	0	39	2	6	11	18	13	249	204	23	103	5	0
108	1718	3	0	0	651	173	196	93	77	86	0	0	0	1	11	0	11	144	80	20	103	5	0
109	1830	9	0	0	802	215	214	131	87	75	0	0	0	0	23	40	35	508	230	16	103	5	0
110	20	0	0	0	6	2	2	1	1	1	0	9	0	2	18	2	0	117	29	19	103	5	0
111	382	0	0	0	231	94	64	28	11	5	0	0	0	1	22	10	16	73	43	19	107	9	0
112	531	3	730	126	410	174	95	36	10	3	0	0	326	1	16	0	40	54	8	21	107	9	0
113	70	0	2024	339	81	34	12	3	0	0	0	3	884	1	24	2	78	149	323	30	107	9	0
114	1411	0	482	422	2132	424	251	100	31	11	0	9	342	1	34	0	0	472	9	30	107	9	0
115	2835	0	554	88	1986	805	498	205	67	26	0	0	273	1	0	0	122	53	0	60	107	9	0
116	887	0	133	69	773	206	146	66	27	14	0	5	80	1	50	69	22	149	232	32	107	9	0
117	872	15	1324	245	797	341	157	51	10	2	0	18	730	1	59	21	86	749	656	67	107	9	0
118	197	0	1403	270	282	69	36	13	3	1	0	6	790	1	53	10	84	440	1716	48	107	9	0
119	17	0	2358	367	16	5	3	1	0	0	0	8	1232	3	67	23	131	579	1273	79	107	9	0
120	1387	0	923	343	1027	373	240	102	35	15	0	0	476	1	19	1	35	99	74	24	107	9	0
121	1901	12	756	497	2121	773	346	108	21	4	0	3	472	1	21	2	31	118	106	35	107	9	0
122	78	0	58	50	238	50	11	2	0	0	49	50	48	18	172	132	203	1692	3177	123	107	9	0
123	77	0	630	107	84	20	13	6	2	1	0	33	280	12	96	81	145	905	882	40	107	9	0
124	1678	0	165	73	1358	546	304	115	32	10	0	0	167	1	0	0	77	73	0	24	107	9	0
125	777	0	63	56	398	176	127	58	24	13	0	0	53	5	54	28	77	354	1784	232	107	9	0
126	587	0	664	351	392	170	104	42	13	5	0	0	383	1	16	0	90	54	9	31	107	9	0
127	1184	16	151	132	998	333	205	84	28	11	0	0	111	2	25	5	49	257	88	32	107	9	0
128	655	0	70	172	570	208	117	50	12	3	0	0	93	1	10	1	12	77	43	19	107	9	0
129	189	0	60	0	196	98	38	4	1	0	11	0	3	0	8	0	7	0	6	4	107	9	0
130	3037	0	355	91	2341	915	542	215	66	23	0	68	282	1	210	91	343	1098	645	84	107	9	0
131	3869	0	849	477	3440	1338	706	255	65	18	0	0	505	1	20	1	62	89	32	91	107	9	0
132	493	10	1072	567	1417	203	95	30	6	0	0	4	965	3	22	4	63	175	101	14	107	9	0
133	11	0	3025	918	27	9	1	0	0	0	0	30	1530	16	173	39	133	1630	4664	163	107	9	0
134	115	27	1059	0	33	6	9	5	5	5	77	2	395	0	5	1	17	46	160	0	107	9	2
135	117	0	1672	561	169	34	24	12	1	0	0	46	837	25	96	42	100	921	509	61	107	9	0
136	40	0	5673	368	117	14	7	0	0	2	0	6	2924	2	31	7	153	308	988	1	107	9	0
137	0	0	0	0	0	0	0	0	0	0	0	9	0	4	58	12	24	532	1839	2	107	9	0
138	0	0	0	0	0	0	0	0	0	0	0	42	0	0	42	25	76	409	184	20	103	5	0
139	3543	0	0	0	1799	614	543	251	132	93	22	11	0	1	23	17	27	234	161	39	103	5	0
140	519	0	0	0	280	117	80	33	20	10	0	10	0	0	15	8	26	255	193	7	103	5	0

YEAR 2030 ORTP DATA BY TAZ

TAZ	POP	GQ	HR	RC	HU	H1	H2	H3	H4	H5	J1	J2	J3	J4	J5	J6	J7	J8	J9	J10	DPSA	NB	MIL
141	729	0	0	0	486	153	121	51	24	14	0	16	0	1	24	19	112	150	53	28	106	8	0
142	694	0	0	0	499	297	126	38	7	1	0	4	0	1	44	15	48	391	252	45	106	8	0
143	2652	1	0	0	1382	520	426	186	93	58	0	11	0	1	20	2	29	184	40	40	106	8	0
144	2211	0	0	0	1089	328	315	142	93	75	0	0	0	1	24	0	0	131	0	28	106	8	0
145	1385	0	0	0	862	431	169	85	27	38	0	19	0	1	49	0	0	655	16	25	106	8	0
146	2398	37	0	0	1303	395	469	175	92	27	0	13	0	0	37	0	0	345	12	8	106	8	0
147	1167	0	0	0	736	324	204	85	29	12	0	0	0	0	18	0	0	79	0	14	106	8	0
148	305	0	0	0	146	42	46	22	13	10	0	5	0	0	0	0	0	71	0	5	106	8	0
149	239	0	0	0	109	38	31	13	10	9	0	1	0	1	0	0	0	42	0	11	106	8	0
150	1011	0	0	0	502	184	152	72	34	31	0	7	0	0	6	11	53	129	124	7	106	8	0
151	645	0	0	0	398	159	122	43	22	2	0	35	0	1	33	18	113	327	164	36	106	8	0
152	138	0	0	0	52	14	15	9	7	7	0	3	0	1	28	9	35	280	32	28	106	8	0
153	352	8	0	0	130	30	34	21	17	18	0	8	0	1	62	45	107	628	168	42	106	8	0
154	1426	5	0	0	808	360	241	105	39	18	11	0	0	1	17	30	42	144	38	58	106	8	0
155	963	0	0	0	452	138	135	61	41	34	0	0	0	1	0	0	0	157	13	19	106	8	0
156	859	1	0	0	452	178	142	60	29	17	0	0	0	1	0	0	0	52	0	13	106	8	0
157	1370	0	0	0	720	271	221	96	48	29	0	0	0	1	0	0	0	131	12	22	106	8	0
158	1714	0	0	0	894	351	281	120	58	35	0	0	0	1	62	22	86	249	80	39	106	8	0
159	896	0	0	0	488	196	152	62	29	16	0	0	0	1	16	16	51	102	30	25	106	8	0
160	629	0	0	0	451	182	122	50	14	0	0	3	0	1	37	19	39	360	293	50	106	8	0
161	316	0	0	0	162	55	39	20	12	14	0	1	0	0	15	0	14	113	31	16	106	8	0
162	214	0	0	0	99	30	28	13	4	12	0	0	0	0	9	0	8	63	24	7	106	8	0
163	448	0	0	0	244	91	80	27	13	10	11	2	0	0	30	39	28	312	121	35	106	8	0
164	688	0	0	0	384	159	120	48	21	9	0	6	0	0	46	40	79	696	232	37	106	8	0
165	592	118	0	0	267	121	69	29	17	10	0	0	0	0	10	1	9	77	40	10	106	8	0
166	674	0	0	0	334	84	108	59	36	11	0	10	0	0	25	0	0	1768	0	1	106	8	0
167	921	25	0	0	538	211	152	61	24	17	0	1	0	0	16	8	21	214	64	18	106	8	0
168	764	0	0	0	417	153	144	60	23	8	0	2	0	1	19	6	34	209	125	44	106	8	0
169	762	0	0	0	455	214	110	54	22	14	0	7	0	0	29	27	76	454	180	24	106	8	0
170	457	0	0	0	260	107	82	36	16	2	0	1	0	0	0	0	0	51	0	10	106	8	0
171	1381	0	0	0	820	371	233	100	33	19	0	2	0	1	24	11	24	116	68	41	106	8	0
172	581	0	0	0	311	118	85	42	19	14	0	2	0	1	19	4	25	145	116	28	106	8	0
173	264	0	0	0	154	45	48	17	11	5	0	1	0	0	6	1	9	96	32	4	106	8	0
174	548	19	0	0	442	226	96	29	5	1	0	0	0	1	21	1	22	131	56	34	106	8	0
175	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	2	15	18	0	106	8	0
176	0	0	0	11	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	109	11	0
177	1391	116	0	90	1003	369	262	71	29	10	0	8	5	0	22	0	1	362	12	44	109	11	0
178	631	0	1115	58	492	208	78	64	12	4	0	18	578	6	156	48	251	414	159	41	109	11	0
179	1013	0	0	0	735	397	185	60	13	3	0	47	0	38	209	87	432	975	344	74	109	11	0
180	360	0	0	0	118	25	31	22	18	22	0	5	0	2	49	5	54	266	191	38	109	11	0
181	1758	0	30	0	1162	689	288	80	35	22	4	6	3	3	37	8	66	183	49	16	109	11	0
182	1270	0	232	131	900	442	267	109	8	0	4	22	138	30	129	66	179	543	300	62	109	11	0
183	1542	18	0	0	1051	525	278	101	26	7	0	15	174	14	137	36	190	598	653	41	109	11	0
184	216	0	0	0	147	77	40	14	3	1	0	15	0	8	64	16	65	553	49	50	109	11	0
185	335	0	0	0	269	84	57	25	9	4	0	53	0	18	391	143	472	1114	878	166	109	11	0
186	3	0	0	0	2	1	0	0	0	0	0	22	0	6	547	81	303	1300	4126	43	109	11	0
187	44	0	0	0	91	5	5	3	2	2	0	25	0	8	201	63	232	555	321	37	109	11	0
188	1749	0	0	0	1022	398	303	125	51	27	0	37	0	12	118	230	1381	1205	1534	218	109	11	0
189	1416	43	0	0	760	271	222	92	51	30	0	24	0	9	87	194	773	799	457	177	109	11	0
190	2129	32	1	0	1296	628	379	153	43	15	0	17	0	2	63	47	72	395	288	69	108	10	0
191	1509	11	2	0	850	339	253	122	49	14	0	18	1	0	42	10	30	582	164	46	108	10	0
192	1579	43	1	0	900	413	244	94	53	24	0	9	1	1	45	21	49	271	302	50	108	10	0
193	719	6	1	18	451	209	129	58	9	6	0	72	8	8	180	162	322	1048	395	36	108	10	0
194	310	0	39	2	187	83	57	23	10	0	0	8	15	1	46	23	50	245	326	12	108	10	0
195	588	0	1	0	347	159	85	49	17	9	0	1	0	0	1	0	0	81	0	14	108	10	0
196	1734	9	1	0	1063	444	325	123	37	20	0	14	1	0	29	5	19	479	34	53	108	10	0
197	183	0	1	0	114	53	27	14	4	3	4	57	1	5	121	91	190	1097	180	11	108	10	0
198	0	0	0	0	0	0	0	0	0	0	0	20	0	1	137	12	47	915	600	38	109	11	0
199	38	34	0	0	1	0	0	0	0	0	60	1	0	1	23	0	16	101	14	0	109	11	0
200	1082	0	0	0	636	261	183	83	30	16	0	3	0	1	15	2	26	228	139	70	109	11	0
201	4186	0	0	0	2418	1008	697	311	123	60	0	1	0	1	17	0	20	176	775	331	109	11	0
202	171	0	0	0	138	43	29	13	5	2	11	29	0	13	249	112	247	585	290	31	109	11	0
203	441	0	0	0	354	111	75	33	12	6	0	8	0	8	122	59	64	248	279	60	109	11	0
204	2886	0	0	0	1364	477	431	194	114	84	0	14	0	13	237	91	135	588	1030	226	109	11	0
205	528	2	0	0	325	82	82	51	23	6	0	16	0	21	354	147	153	867	1828	69	109	11	0
206	4370	0	0	0	3602	1002	754	289	132	78	0	23	0	19	325	128	224	961	1302	504	109	11	0
207	17	17	0	0	0	0	0	0	0	0	0	3	0	0	22	0	16	107	28	21	109	11	0
208	217	4	0	0	148	67	39	15	4	1	0	17	0	2	50	6	23	233	4	65	109	11	0
209	103	0	0	0	70	32	18	7	2	1	11	119	0	16	331	146	79	1276	214	66	109	11	0
210	1441	36	0	0	969	437	252	98	29	10	0	112	0	10	395	96	121	2037	743	440	109	11	0

YEAR 2030 ORTP DATA BY TAZ

TAZ	POP	GQ	HR	RC	HU	H1	H2	H3	H4	H5	J1	J2	J3	J4	J5	J6	J7	J8	J9	J10	DPSA	NB	MIL
211	3476	0	0	0	2473	957	606	254	86	35	0	152	0	26	459	238	99	721	306	260	109	11	0
212	2661	0	0	0	1850	843	479	184	53	17	0	104	0	12	269	105	98	570	250	223	109	11	0
213	1173	0	0	0	570	219	184	82	43	28	0	184	0	26	477	243	112	702	277	68	109	11	0
214	2298	0	0	0	1974	1578	299	43	2	0	0	62	0	8	211	61	70	542	158	222	109	11	0
215	543	0	0	0	375	169	98	38	11	4	0	204	0	11	278	103	176	635	86	77	109	11	0
216	2165	0	0	0	1497	503	357	162	65	34	0	157	0	28	481	256	94	677	295	167	109	11	0
217	1344	9	0	0	1111	505	245	82	18	4	0	134	0	11	333	106	129	676	382	106	109	11	0
218	1419	0	0	0	954	433	256	100	30	10	16	101	0	5	159	43	96	394	146	99	109	11	0
219	328	0	0	0	222	104	56	23	6	3	0	45	0	1	86	17	53	235	94	28	109	11	0
220	293	55	0	0	180	106	43	12	2	0	27	981	0	3	336	36	392	4000	99	53	109	11	0
221	2053	0	0	0	1202	571	339	122	55	39	0	341	0	1	146	23	225	941	101	34	111	13	0
222	322	0	0	0	164	53	48	28	15	6	0	19	0	0	4	0	0	176	2	5	111	13	0
223	852	372	0	0	284	106	99	62	8	0	0	246	0	1	137	11	146	1037	110	30	111	13	0
224	0	0	0	0	0	0	0	0	0	0	0	673	0	1	168	15	125	3198	16	8	111	13	0
225	0	0	0	0	0	0	0	0	0	0	0	783	0	7	96	20	135	764	47	36	111	13	0
226	0	0	0	0	0	0	0	0	0	0	0	540	0	7	82	19	131	452	45	33	111	13	0
227	0	0	0	0	0	0	0	0	0	0	0	320	0	5	50	13	86	230	31	11	111	13	0
228	0	0	0	0	0	0	0	0	0	0	0	778	0	9	104	33	189	481	153	27	111	13	0
229	0	0	0	0	0	0	0	0	0	0	0	519	0	7	83	21	143	381	49	33	111	13	0
230	330	0	0	0	240	148	60	17	3	0	0	88	0	3	36	6	27	193	57	49	111	13	0
231	558	42	0	0	372	243	78	19	5	7	0	158	0	2	41	8	48	186	186	42	111	13	0
232	212	0	0	0	158	85	51	17	1	0	0	369	0	3	47	12	67	336	36	17	111	13	0
233	44	0	0	0	33	18	10	4	0	0	55	923	0	11	109	38	215	517	74	10	111	13	0
234	1243	1243	0	0	0	0	0	0	0	0	142	271	3	17	75	52	29	148	115	33	111	13	0
235	742	0	0	0	634	234	134	52	15	5	0	250	1	16	179	47	61	575	552	161	111	13	0
236	0	0	0	0	0	0	0	0	0	0	0	74	0	5	37	16	19	95	42	15	111	13	0
237	0	0	0	0	0	0	0	0	0	0	0	740	0	10	96	31	181	448	61	21	111	13	0
238	528	0	0	0	352	139	133	23	10	3	0	17	0	1	22	5	47	75	5	15	111	13	0
239	0	0	0	0	0	0	0	0	0	0	16	266	0	13	361	76	783	1262	84	12	111	13	0
240	0	0	0	0	0	0	0	0	0	0	0	265	0	13	359	75	778	1253	83	11	111	13	0
241	101	0	0	0	34	43	0	16	1	1	0	163	0	9	277	46	529	977	118	14	111	13	0
242	0	0	0	0	0	0	0	0	0	0	0	320	0	16	452	86	921	1739	124	22	111	13	0
243	0	0	0	0	0	0	0	0	0	0	0	377	0	19	530	107	1125	1857	126	27	111	13	0
244	138	9	0	0	108	39	23	9	3	1	33	170	0	9	285	48	544	1007	142	44	111	13	0
245	0	0	0	0	0	0	0	0	0	0	0	190	0	9	256	54	556	895	59	12	111	13	0
246	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	111	13	0
247	64	64	0	0	0	0	0	0	0	0	0	14	0	0	6	0	0	288	0	0	111	13	0
248	906	0	0	0	582	300	178	49	20	5	0	5	0	0	2	0	0	78	0	0	111	13	0
249	1578	0	0	0	1077	615	277	108	16	4	0	14	0	1	51	4	41	424	339	133	111	13	0
250	242	0	0	0	149	86	27	24	4	2	0	27	0	1	50	8	55	416	114	89	111	13	0
251	2013	0	0	0	1179	548	369	140	51	19	0	3	0	0	1	0	0	52	1	0	111	13	0
252	189	11	0	0	152	57	32	12	4	1	0	314	27	15	510	89	953	1819	467	32	111	13	0
253	579	0	0	0	494	181	104	41	12	4	0	22	1	7	109	29	51	258	104	79	111	13	0
254	342	0	15	0	241	152	47	24	5	1	0	14	1	2	64	4	83	237	41	21	111	13	0
255	331	0	47	70	298	147	74	11	1	0	0	261	47	13	402	75	784	1374	348	28	111	13	0
256	247	0	0	0	281	77	44	17	5	2	0	339	0	20	534	108	1020	1795	171	60	111	13	0
257	0	0	0	0	0	0	0	0	0	0	0	33	0	1	171	13	146	520	690	1	111	13	0
258	0	0	0	0	0	0	0	0	0	0	0	66	0	3	91	19	193	318	36	3	111	13	0
259	0	0	0	0	0	0	0	0	0	0	0	9	0	36	36	145	51	223	82	28	111	13	0
260	1133	0	0	0	569	217	191	82	38	23	0	17	0	12	22	56	182	311	62	48	111	13	0
261	1278	0	0	0	655	270	202	86	45	27	0	6	0	6	18	23	79	198	114	69	111	13	0
262	443	0	0	0	349	183	97	15	5	0	0	2	7	1	12	5	31	108	94	22	111	13	0
263	368	0	0	0	293	172	50	28	2	1	0	7	2	6	17	24	84	186	101	43	111	13	0
264	1638	0	0	0	874	299	331	116	40	23	0	4	6	3	28	13	56	252	182	71	111	13	0
265	1543	54	0	0	757	309	169	103	71	46	0	3	1	1	4	8	26	71	121	21	111	13	0
266	193	0	0	0	123	94	39	1	0	3	0	9	0	4	119	12	78	311	260	43	111	13	0
267	3153	0	0	0	1584	600	513	232	128	62	0	1	0	0	0	0	0	0	0	0	111	13	0
268	915	0	0	0	782	288	165	64	18	6	0	4	0	3	30	4	28	137	27	93	111	13	0
269	271	0	0	0	231	85	49	19	5	2	0	3	0	0	21	1	14	119	23	28	111	13	0
270	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	7	0	0	111	13	0
271	1339	0	0	0	692	276	191	77	52	42	0	32	0	0	26	23	61	390	117	18	110	12	0
272	2203	13	0	0	889	240	227	127	102	111	0	16	0	0	19	8	33	254	159	6	110	12	0
273	3052	0	0	0	1485	447	515	214	126	73	0	10	0	0	22	3	29	153	15	67	110	12	0
274	1785	34	0	0	1012	450	299	130	47	21	0	9	0	1	18	0	0	133	0	27	108	10	0
275	3071	0	0	0	1831	751	579	207	93	29	4	3	0	1	15	0	0	68	6	32	108	10	0
276	2811	0	0	0	1533	638	397	233	82	59	0	40	0	0	32	0	0	196	17	33	108	10	0
277	2391	0	0	0	1306	514	397	158	83	50	0	0	0	0	112	11	28	141	8	21	108	10	0
278	3600	0	0	0	1971	751	602	260	115	64	0	0	0	1	57	5	39	131	74	33	108	10	0
279	871	4	0	0	599	289	158	58	16	5	0	12	0	1	0	0	22	428	25	28	108	10	0
280	3532	75	0	0	2204	1027	614	246	76	28	0	0	19	1	30	17	65	132	30	53	108	10	0

YEAR 2030 ORTP DATA BY TAZ

TAZ	POP	GQ	HR	RC	HU	H1	H2	H3	H4	H5	J1	J2	J3	J4	J5	J6	J7	J8	J9	J10	DPSA	NB	MIL
281	4949	288	0	0	2635	1115	777	349	137	68	0	17	0	1	45	57	79	750	0	53	108	10	0
282	1073	22	0	0	425	116	123	67	49	48	0	0	0	1	0	0	46	602	0	58	108	10	0
283	889	0	0	0	360	93	100	56	42	42	4	12	0	1	24	0	92	157	51	27	108	10	0
284	1867	0	0	0	447	53	70	83	67	157	0	0	0	1	10	0	6	94	4	9	110	12	0
285	4005	0	0	0	1530	334	422	267	220	215	0	0	0	13	37	9	16	252	55	50	110	12	0
286	3259	21	0	0	1272	324	384	217	161	137	0	15	0	8	15	21	86	644	71	59	110	12	0
287	1079	85	0	0	455	137	126	77	46	31	0	0	0	1	4	0	11	81	17	13	110	12	0
288	1465	0	0	0	882	386	303	71	33	24	0	6	0	1	3	2	15	327	19	9	110	12	0
289	700	6	0	0	247	44	85	43	39	32	0	13	0	0	18	2	27	193	5	8	112	14	0
290	1938	0	0	0	699	175	162	124	80	122	0	2	0	0	7	1	13	43	5	18	112	14	0
291	274	89	0	0	67	12	22	14	11	7	0	6	0	0	25	1	26	111	80	2	110	12	0
292	320	48	0	0	108	37	28	11	15	12	0	0	0	0	3	0	2	34	1	9	110	12	0
293	602	0	0	0	227	52	71	37	34	26	0	5	0	0	8	0	4	105	2	9	110	12	0
294	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	110	12	0
295	2327	0	0	0	888	249	244	141	116	111	0	1	4	1	10	0	9	136	6	33	112	14	0
296	1870	236	0	0	616	152	182	109	68	84	0	5	1	1	28	30	22	2120	62	26	112	14	0
297	847	39	0	0	287	59	82	50	42	45	0	1	1	1	8	1	5	409	6	8	112	14	0
298	1167	89	0	0	543	248	145	57	44	30	16	19	0	0	8	7	23	850	12	13	112	14	0
299	1137	2	0	0	477	101	159	89	53	42	0	9	0	0	4	9	23	338	18	17	112	14	0
300	1372	200	0	0	535	156	182	67	41	45	16	56	0	0	7	62	112	1999	192	31	112	14	0
301	988	177	0	0	344	97	103	52	42	30	0	10	0	0	5	18	39	256	30	6	112	14	0
302	2062	106	0	0	657	129	166	112	85	129	0	9	0	1	17	5	13	272	23	26	112	14	0
303	935	11	0	0	388	100	106	65	55	36	0	28	0	0	30	79	31	525	62	12	112	14	0
304	306	38	0	0	78	6	21	15	10	20	0	4	0	0	3	4	10	75	8	9	113	15	0
305	1952	0	0	0	749	278	203	62	59	127	0	1	0	0	1	0	1	58	9	13	113	15	0
306	1280	0	0	0	422	84	89	86	53	85	0	1	0	0	6	2	9	79	88	6	113	15	0
307	399	12	0	0	103	0	20	22	20	34	0	6	0	0	11	6	27	251	10	5	113	15	0
308	643	0	0	0	166	15	41	30	20	54	0	11	0	0	14	4	13	434	7	4	113	15	0
309	1878	0	0	0	626	94	153	108	94	131	0	10	0	0	0	1	16	189	431	13	112	14	0
310	3439	5	0	0	1064	181	218	195	157	252	4	23	0	1	0	1	16	270	91	25	112	14	0
311	707	0	0	0	223	29	57	36	41	48	0	136	0	0	0	3	86	977	98	8	112	14	0
312	4308	96	0	0	1022	59	139	157	187	425	0	0	0	1	0	9	27	349	21	17	114	16	0
313	1676	57	0	0	437	37	65	75	68	156	0	0	0	0	0	14	12	168	30	18	114	16	0
314	1909	32	0	0	372	5	19	37	62	237	0	0	0	1	0	0	0	149	12	18	114	16	0
315	2007	39	0	0	428	24	63	66	58	198	0	1	0	0	0	0	0	264	26	11	113	15	0
316	2072	0	0	0	613	59	103	99	98	180	0	6	0	1	0	17	72	395	0	26	113	15	0
317	4207	52	0	0	1007	97	162	149	156	393	0	0	0	1	27	27	68	236	62	26	113	15	0
318	1519	151	0	0	318	21	26	49	61	154	0	26	0	8	24	0	8	84	0	12	114	16	0
319	1017	5	0	0	241	23	38	45	42	88	0	9	0	1	9	0	5	53	0	2	114	16	0
320	264	20	0	0	59	3	11	12	11	20	0	107	0	16	36	0	6	195	0	16	114	16	0
321	896	0	0	0	240	17	56	39	43	82	0	1	0	0	6	0	3	43	0	2	114	16	0
322	2536	104	0	0	569	19	52	74	96	274	0	43	0	13	0	0	0	334	23	22	114	16	0
323	4400	63	0	0	1165	110	200	199	201	390	0	23	0	2	26	2	0	262	0	38	114	16	0
324	0	0	0	0	0	0	0	0	0	0	0	4	0	0	6	9	0	12	0	2	114	16	0
325	1259	2	0	1	538	210	147	68	44	58	11	0	1	0	21	17	22	480	137	0	113	15	0
326	2501	0	24	2	968	211	287	169	135	115	0	0	12	0	42	5	177	151	31	36	113	15	0
327	0	0	0	0	0	0	8	2	0	0	0	0	0	0	4	0	4	25	2	0	113	15	0
328	123	109	0	0	7	2	2	1	0	1	0	47	0	8	182	200	120	822	455	10	113	15	0
329	578	0	0	0	388	140	97	44	17	7	0	14	0	5	103	110	59	319	184	40	113	15	0
330	0	0	0	0	0	0	0	0	0	0	0	45	0	19	219	475	53	530	248	25	113	15	0
331	0	0	0	0	0	0	0	0	0	0	0	47	0	18	212	447	63	576	260	24	113	15	0
332	184	174	0	0	7	3	2	1	0	0	16	43	0	43	806	166	52	571	132	37	113	15	2
333	1595	119	0	0	630	168	175	94	68	66	0	171	0	57	972	1353	311	2572	1546	234	113	15	0
334	987	43	0	0	705	275	167	68	21	8	11	38	0	8	143	169	68	825	233	50	113	15	0
335	1579	0	0	0	447	53	87	79	75	131	0	12	0	1	40	0	14	127	26	26	113	15	0
336	651	28	0	0	182	20	39	37	28	47	0	14	0	0	13	13	34	217	104	14	113	15	0
337	1085	0	0	0	414	81	88	61	57	70	0	4	0	0	6	0	8	110	15	13	113	15	0
338	1984	0	0	0	578	0	113	155	155	136	0	3	0	0	22	2	23	159	62	31	113	15	0
339	716	0	0	0	203	26	38	40	31	55	0	5	0	0	34	15	58	170	164	9	113	15	0
340	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	113	15	0
341	1786	0	0	0	599	124	155	107	87	110	0	37	0	1	16	5	14	371	79	40	113	15	0
342	1954	0	0	0	589	83	125	105	94	150	0	5	0	0	0	2	35	87	27	17	113	15	0
343	160	0	0	0	86	27	24	11	6	4	0	56	0	18	281	442	118	952	543	47	113	15	0
344	0	0	0	0	0	0	0	0	0	0	0	21	0	7	114	145	48	467	209	33	113	15	0
345	68	0	0	0	24	4	6	4	3	4	4	82	0	1	30	105	310	397	234	36	113	15	0
346	323	0	0	0	102	17	24	18	16	23	0	147	0	1	68	314	304	504	215	57	113	15	0
347	0	0	0	0	0	0	0	0	0	0	0	64	0	12	170	372	93	269	138	7	113	15	0
348	902	0	0	0	386	106	71	51	37	59	0	72	0	12	200	387	119	376	315	7	113	15	0
349	221	0	0	0	86	16	18	13	9	16	0	158	0	28	450	897	216	779	482	17	113	15	0
350	183	0	0	0	119	42	23	4	6	9	0	146	0	25	371	796	214	622	329	15	113	15	0

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TAZ	POP	GQ	HR	RC	HU	H1	H2	H3	H4	H5	J1	J2	J3	J4	J5	J6	J7	J8	J9	J10	DPSA	NB	MIL
351	0	0	0	0	0	0	0	0	0	0	87	56	0	9	162	305	96	310	294	6	113	15	0
352	255	0	0	0	84	0	37	29	17	4	0	17	0	2	69	65	35	164	112	1	113	15	0
353	556	0	0	0	184	13	47	31	33	34	0	44	0	8	151	239	70	297	220	5	113	15	0
354	2890	4	0	0	628	20	65	96	116	305	0	0	0	1	65	11	22	125	71	25	113	15	0
355	4455	757	0	0	940	77	143	161	154	351	0	5	0	10	696	446	61	468	404	45	113	15	0
356	853	0	0	0	258	21	45	34	52	85	16	7	0	10	801	441	191	655	275	37	113	15	0
357	1050	4	0	0	273	0	33	62	71	92	0	0	0	0	35	6	55	127	28	9	113	15	0
358	2074	31	0	0	441	2	12	47	96	265	0	5	0	1	16	17	117	183	31	28	113	15	0
359	247	0	0	0	96	14	22	11	13	17	0	1070	0	0	116	28	45	350	271	34	117	19	1
360	1393	255	0	0	517	70	89	70	54	74	1087	4	0	0	27	0	20	107	16	0	115	17	1
361	3370	22	0	0	1138	213	342	219	150	196	0	8	0	0	7	1	7	167	8	12	115	17	0
362	2052	68	0	0	622	184	116	80	76	157	0	307	0	1	48	20	29	3911	123	37	115	17	2
363	969	295	0	0	246	10	54	60	67	21	683	2	0	0	11	0	9	0	6	0	115	17	1
364	1622	10	0	0	647	188	200	89	79	69	0	0	0	0	7	22	7	64	3	15	116	18	0
365	4359	101	0	0	1955	735	611	159	138	177	0	1	0	0	37	63	25	237	122	45	116	18	0
366	9704	2	0	0	4117	1127	1156	728	491	377	0	35	0	0	26	44	50	359	39	2	116	18	0
367	1768	26	0	0	580	75	203	125	76	95	0	0	0	0	9	0	9	180	176	2	116	18	0
368	6290	139	0	0	1504	105	220	248	271	607	0	0	0	1	40	5	46	145	77	26	116	18	0
369	6119	0	0	0	2234	182	313	295	289	526	4331	2687	0	0	366	1239	79	3865	1319	44	116	18	1
370	2787	0	0	0	1021	254	286	174	133	146	0	35	0	1	21	0	0	133	0	20	115	17	1
371	1188	1184	0	0	1	1	0	1	0	0	1863	634	0	25	214	900	57	658	330	36	118	20	2
372	1322	0	0	0	424	6	70	89	84	105	0	1	0	0	6	0	4	0	4	5	116	18	1
373	4335	86	0	0	1255	227	258	232	193	314	0	264	0	1	110	22	37	305	266	22	116	18	0
374	1024	0	0	0	545	184	210	68	45	8	11	79	0	0	8	0	2	44	2	7	116	18	0
375	4966	33	0	0	1620	324	413	293	241	313	27	43	0	6	318	755	44	822	220	44	118	20	1
376	213	182	0	0	10	0	3	1	1	3	0	1	0	0	12	0	8	46	6	0	118	20	1
377	0	0	0	0	1	0	0	0	0	0	0	124	0	8	304	659	195	709	622	19	117	19	0
378	20	20	0	0	0	0	0	0	0	0	0	130	0	11	402	860	195	876	1084	25	117	19	0
379	3379	0	0	0	1144	179	247	192	164	237	9	12	0	0	0	0	0	389	43	23	117	19	1
380	11	6	113	6	2	1	0	0	1	0	120	122	44	3	1102	142	101	417	324	14	117	19	0
381	115	0	258	36	98	35	21	8	2	1	0	403	110	7	3187	286	422	1774	1773	34	117	19	0
382	6	6	569	145	0	0	0	0	0	0	0	323	318	9	2612	337	232	1078	495	110	117	19	0
383	0	0	0	0	0	0	0	0	0	0	0	10	0	0	63	3	15	49	52	0	117	19	0
384	1033	367	0	0	184	24	39	34	32	54	0	59	0	0	304	20	92	307	131	33	117	19	1
385	2275	1	0	0	626	83	132	116	109	184	0	11	0	0	45	1	20	141	9	23	117	19	1
386	2019	0	0	0	754	147	204	125	110	108	27	97	0	0	93	0	36	497	97	15	117	19	1
387	1049	0	0	0	411	106	120	85	36	46	4	1	0	0	12	11	8	99	53	18	117	19	1
388	120	0	0	0	96	26	0	0	5	12	0	80	0	0	26	0	2	145	19	2	117	19	1
389	5554	6	0	0	1751	288	401	314	269	393	3781	1998	0	13	217	148	110	1452	1059	41	117	19	1
390	151	8	0	0	11	41	0	0	0	21	106	4	0	0	29	0	23	114	17	0	117	19	1
391	371	0	0	0	352	8	58	38	26	6	0	0	0	0	0	0	0	0	0	14	117	19	1
392	1284	1133	0	0	57	1	19	19	9	4	3827	0	0	0	0	0	0	0	0	2	117	19	1
393	281	0	0	0	113	12	32	17	23	10	1092	1	0	0	7	0	5	26	4	4	117	19	2
394	144	0	0	0	27	4	0	4	5	14	918	1533	0	0	328	2234	167	1252	1268	19	117	19	2
395	3566	0	0	0	1007	116	193	177	169	299	0	61	0	13	42	28	0	300	242	41	118	19	0
396	0	0	0	0	0	0	0	0	0	0	0	2	0	0	13	0	0	0	9	0	118	20	0
397	44	0	0	0	32	16	8	2	0	1	0	0	0	0	2	0	1	7	1	1	118	20	2
398	961	321	0	0	206	67	48	24	0	64	273	0	0	0	0	0	0	0	0	1	118	20	1
399	652	0	0	0	193	11	41	32	69	34	16	1	0	0	9	0	9	35	12	1	118	20	2
400	404	10	0	0	107	20	20	17	12	35	0	5	0	0	8	2	9	94	49	3	118	20	0
401	1292	11	0	0	389	66	97	68	48	106	0	20	0	2	25	8	42	226	199	13	118	20	0
402	546	7	0	0	130	12	26	20	17	48	0	38	0	4	35	12	66	384	280	5	118	20	2
403	1398	17	0	0	456	91	105	98	60	90	0	42	0	36	73	82	41	309	160	25	118	20	0
404	296	22	0	0	90	23	23	13	12	17	4	0	0	0	1	0	1	78	0	1	118	20	0
405	4721	21	0	0	1627	357	434	291	230	273	0	32	0	1	61	11	51	628	71	45	118	20	0
406	4172	6	24	0	1552	264	484	309	229	192	0	10	3	0	0	17	50	114	62	10	118	20	0
407	4200	0	2	0	2219	903	726	248	143	85	0	9	0	0	0	0	4	102	14	14	118	20	0
408	1073	0	1	0	635	287	210	61	31	12	0	10	0	0	0	0	11	52	65	2	118	20	0
409	1696	0	3	0	663	144	174	121	81	82	0	5	0	1	5	16	43	109	112	8	118	20	0
410	916	13	2	0	270	50	60	51	43	60	0	1	0	0	2	2	21	70	125	3	118	20	0
411	262	0	2	0	91	12	23	10	16	19	0	24	0	7	78	135	118	338	690	24	118	20	0
412	137	0	1	70	71	32	17	8	4	5	410	10	27	3	15	55	73	178	400	9	118	20	0
413	68	1	0	0	20	3	5	4	3	5	0	65	0	3	80	53	443	1780	2157	42	118	20	0
414	3279	0	0	0	1127	526	177	48	45	307	0	0	0	0	0	0	2	42	2	7	119	21	0
415	1205	0	0	0	407	90	101	79	65	67	0	0	0	0	0	0	2	40	1	4	119	21	0
416	1630	0	0	0	593	184	154	86	45	111	0	41	0	0	0	0	4	152	39	7	119	21	0
417	0	0	0	0	0	0	0	0	0	0	0	96	0	0	0	0	4	420	3	0	119	21	0
418	3185	17	0	0	1114	114	373	274	214	113	0	0	0	0	0	0	2	0	1	10	119	21	0
419	478	0	0	0	168	45	47	27	14	32	0	0	0	0	0	0	1	40	1	1	119	21	0
420	947	11	2	0	314	86	81	42	43	57	0	0	0	0	0	0	2	30	0	7	118	20	0

YEAR 2030 ORTP DATA BY TAZ

TAZ	POP	GQ	HR	RC	HU	H1	H2	H3	H4	H5	J1	J2	J3	J4	J5	J6	J7	J8	J9	J10	DPSA	NB	MIL
421	4947	28	0	0	1649	198	432	360	320	262	0	1	0	0	0	39	23	178	25	4	119	21	0
422	1792	13	0	0	567	54	192	124	98	91	0	0	0	0	0	0	1	0	1	5	119	21	0
423	1174	1	0	0	391	67	115	74	50	76	0	0	0	0	9	0	8	75	6	2	119	21	0
424	897	20	0	0	275	45	85	48	33	59	0	2	0	0	73	70	74	481	464	14	119	21	0
425	494	0	0	0	167	54	12	28	36	29	0	0	0	0	28	17	34	243	293	8	119	21	0
426	0	0	0	0	0	0	0	0	0	0	0	2	0	0	77	103	50	370	229	18	119	21	0
427	155	0	0	0	60	7	11	10	12	9	0	1	0	0	21	9	61	216	209	1	119	21	0
428	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	119	21	0
429	496	14	0	0	141	25	32	19	21	39	0	73	0	0	99	31	17	189	113	20	119	21	0
430	725	110	0	0	338	185	89	25	18	18	0	62	0	0	69	9	16	434	310	47	119	21	0
431	961	0	0	0	379	51	143	87	53	26	0	44	0	2	157	34	10	393	281	51	119	21	0
432	4542	2490	0	0	647	84	156	131	135	120	273	0	0	0	0	0	0	0	0	33	119	21	1
433	3574	0	0	0	1511	415	423	231	160	153	33	65	0	2	158	47	42	413	828	91	119	21	2
434	1094	0	0	0	339	36	75	62	62	82	0	0	0	0	4	0	2	0	0	3	119	21	0
435	2665	10	0	0	848	178	220	140	110	190	0	22	0	0	0	17	0	362	18	12	119	21	0
436	2610	0	0	0	804	135	193	166	147	161	0	41	0	1	0	5	0	195	5	13	119	21	0
437	4933	62	0	0	1511	273	369	281	237	334	0	2	0	13	41	11	19	295	28	4	119	21	0
438	0	0	0	0	0	0	0	0	0	0	44	129	0	9	246	404	20	220	136	33	119	21	2
439	6791	21	0	0	2066	349	487	383	329	481	0	17	0	13	24	0	39	283	52	31	119	21	2
440	1376	0	0	0	552	120	175	98	75	51	0	0	0	2	4	0	0	85	0	34	302	22	0
441	5443	178	0	0	1180	81	183	180	210	490	0	35	0	0	40	3	19	1160	26	22	302	22	0
442	2303	42	0	0	485	0	23	101	169	193	0	17	0	1	17	1	19	347	12	20	302	22	0
443	0	0	0	0	0	0	0	0	0	0	0	167	0	0	0	0	0	80	0	10	302	22	2
444	620	3	0	0	157	0	27	39	42	46	0	18	0	3	5	3	13	198	23	8	302	22	0
445	341	7	0	0	79	8	15	15	6	34	0	12	0	2	7	3	24	137	77	1	302	22	0
446	1166	25	0	0	377	59	87	63	46	80	0	26	0	13	16	16	44	197	125	6	302	22	0
447	1479	0	0	0	536	83	139	113	143	33	0	66	0	12	29	16	89	527	291	33	302	22	0
448	1209	52	0	0	257	15	44	37	39	110	0	2	0	0	2	0	8	68	10	5	302	22	0
449	2513	134	0	0	534	17	57	86	121	242	0	11	0	0	0	0	0	418	81	26	302	22	0
450	3333	212	0	0	714	93	126	87	106	287	0	0	0	0	0	23	14	19	0	16	302	22	0
451	4330	252	0	0	977	0	106	228	312	319	0	27	0	4	32	190	55	617	64	130	302	22	0
452	1245	30	0	0	302	25	80	53	41	99	0	1	0	0	0	0	9	93	0	3	302	22	0
453	1017	24	0	0	359	43	74	49	83	50	0	0	0	1	2	0	10	249	11	4	302	22	0
454	2383	61	0	0	733	52	126	137	123	185	0	14	0	17	38	297	56	253	272	19	302	22	0
455	334	0	0	0	76	4	14	15	13	29	0	17	0	19	43	340	64	217	358	14	302	22	0
456	1870	0	0	0	615	62	69	138	196	84	0	20	0	0	117	0	86	302	602	43	302	22	0
457	2769	34	0	0	764	48	149	132	138	232	0	10	0	0	31	0	119	304	189	2	302	22	0
458	2148	44	0	0	486	30	103	86	81	176	0	1	0	0	3	17	16	123	28	3	302	22	0
459	1588	36	0	0	345	22	68	48	55	143	0	1	0	0	2	0	14	257	12	0	302	22	0
460	2119	0	0	0	887	187	254	159	118	81	0	1	0	1	0	0	0	108	0	125	303	22	0
461	1763	0	0	0	732	155	243	118	94	61	0	29	0	1	17	27	290	898	1872	113	303	22	0
462	1683	0	0	0	656	134	209	133	106	54	0	5	0	1	7	5	112	204	389	35	303	22	0
463	1770	0	0	0	818	250	314	116	66	43	0	3	0	0	1	2	1	85	69	41	303	22	2
464	2661	63	0	0	644	42	144	108	104	232	0	0	0	1	0	0	6	171	6	9	304	21	0
465	1479	7	0	0	559	101	189	119	81	54	0	2	0	0	2	0	2	35	2	1	304	22	0
466	2334	0	0	0	846	153	222	168	191	89	0	1	0	0	0	0	4	9	4	2	304	22	0
467	3928	0	0	0	1595	448	391	272	245	166	0	2	0	0	11	5	12	38	81	4	304	22	0
468	346	305	0	0	11	0	3	2	3	3	0	45	0	19	172	292	52	1177	150	32	304	25	0
469	1323	0	0	0	508	97	155	109	98	36	0	47	0	0	207	422	36	313	210	27	304	22	0
470	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	305	21	0
471	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	305	21	0
472	4458	0	0	0	1913	426	800	358	187	79	0	0	0	10	0	0	9	880	8	319	306	25	2
473	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	10	0	305	21	0
474	1546	0	0	0	565	111	172	107	88	68	0	0	0	1	4	3	82	205	38	83	305	21	0
475	15082	0	0	0	5517	1087	1677	1049	863	659	0	7	0	14	7	5	0	926	2	875	305	21	0
476	0	0	0	0	0	0	0	0	0	0	0	2	0	5	67	92	497	2506	1476	15	305	21	0
477	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	305	21	0
478	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	305	21	0
479	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	305	21	0
480	6639	0	0	0	2429	479	738	462	380	290	0	0	0	6	0	0	0	387	0	379	305	21	0
481	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	8	0	10	0	306	25	2
482	1214	0	0	0	362	20	81	92	86	73	0	3	0	12	0	17	11	140	15	11	306	25	0
483	2189	0	0	0	703	60	182	163	164	117	0	0	0	0	0	0	4	0	6	5	306	25	0
484	2512	0	0	0	864	219	257	129	103	137	0	1	0	7	0	17	19	174	253	13	306	25	0
485	2532	0	0	0	973	233	316	161	125	104	0	5	0	0	0	0	0	300	50	19	306	25	0
486	1148	0	0	0	350	22	82	93	87	62	0	0	0	0	0	0	0	0	8	4	306	25	0
487	2122	0	0	0	640	42	140	156	160	121	0	0	0	0	13	0	11	163	18	0	306	25	2
488	2181	0	0	0	745	84	202	160	159	104	0	0	0	0	1	0	10	33	6	0	306	25	0
489	1443	0	0	0	448	34	106	96	135	69	0	0	0	0	1	0	11	0	11	0	306	25	2
490	851	0	0	0	257	25	55	59	69	48	38	14	0	0	41	33	94	570	811	19	306	25	0

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TAZ	POP	GQ	HR	RC	HU	H1	H2	H3	H4	H5	J1	J2	J3	J4	J5	J6	J7	J8	J9	J10	DPSA	NB	MIL
491	767	0	0	0	306	184	156	0	0	45	0	1	0	0	1	0	4	122	4	5	306	25	0
492	2799	0	0	0	1013	208	301	198	151	126	0	0	0	0	1	0	9	92	9	13	306	25	0
493	11135	2	0	0	4321	908	1324	806	748	381	0	2	0	2	44	2	52	347	8	285	307	35	0
494	4040	0	0	0	1765	438	621	290	139	140	0	1	0	3	44	9	13	300	8	131	307	35	0
495	2389	0	0	0	1043	289	391	159	56	87	0	20	0	6	641	69	247	2349	152	110	307	26	0
496	2316	7	0	0	1133	327	392	189	125	23	0	0	0	0	0	11	99	92	9	21	306	25	0
497	1229	14	0	0	354	28	93	73	52	89	0	0	0	0	0	0	14	43	7	0	306	25	0
498	882	0	0	0	256	18	52	58	74	50	0	0	0	0	0	0	7	0	4	0	306	25	0
499	617	0	0	0	225	31	66	35	30	38	0	0	0	0	0	11	6	62	17	8	306	25	0
500	1303	0	0	0	438	65	129	94	85	59	0	3	0	0	6	0	14	178	12	4	306	25	0
501	664	2	0	0	261	66	53	36	44	33	0	17	0	0	136	17	213	984	506	31	306	25	0
502	650	0	0	0	222	44	78	37	26	37	0	0	0	0	2	0	13	66	11	3	306	25	0
503	1238	0	0	0	399	48	110	91	73	68	0	1	0	0	3	0	19	0	16	2	306	25	0
504	1481	0	0	0	513	81	129	113	98	73	0	0	0	0	0	0	7	50	5	3	306	25	0
505	1366	2	0	0	423	36	132	83	83	78	0	0	0	2	0	1	18	161	8	3	306	25	0
506	840	0	0	0	460	175	175	63	25	0	0	0	0	10	0	4	75	104	102	25	306	25	0
507	26	0	0	0	0	8	3	0	0	2	0	0	0	0	1	0	0	14	2	0	309	26	1
508	97	0	0	0	0	28	10	0	0	8	645	1	0	0	2	0	0	46	8	0	309	26	0
509	2809	346	0	0	855	21	168	223	223	104	0	0	0	0	1	0	0	12	2	26	309	26	1
510	25	0	0	0	0	7	3	0	0	2	0	0	0	0	1	0	0	11	2	0	309	26	1
511	159	0	0	0	0	45	17	0	0	13	0	1	0	0	4	0	0	74	13	0	309	26	2
512	15	0	0	0	0	5	2	0	0	1	645	589	0	0	174	0	0	412	48	0	309	26	0
513	2556	15	0	0	888	128	242	183	147	127	11	11	0	0	0	0	54	257	32	6	308	26	0
514	2199	14	0	0	754	143	199	137	138	108	0	1	0	0	4	11	32	83	10	22	308	26	0
515	436	0	0	0	148	27	39	29	24	26	0	9	0	0	1	0	5	126	41	5	308	26	0
516	1510	7	0	0	581	122	198	104	81	61	60	36	0	0	3	0	9	493	9	9	308	26	0
517	1552	9	0	0	566	147	150	83	75	92	0	39	0	4	41	20	37	265	186	9	308	26	0
518	608	11	0	0	295	93	75	42	24	20	0	38	0	1	24	7	32	232	112	5	308	26	0
519	1312	90	0	0	523	119	110	66	50	84	607	156	0	5	84	28	83	799	306	6	308	26	0
520	928	6	0	0	375	0	184	112	89	0	0	95	0	10	64	48	41	446	109	29	308	26	0
521	1072	21	11	0	347	40	84	67	53	68	0	57	1	2	34	13	54	241	117	6	308	26	0
522	1321	0	7	13	508	87	109	71	69	85	172	17	7	1	16	5	23	122	77	5	308	26	0
523	987	22	5	0	486	139	111	72	36	41	173	20	1	0	7	1	9	110	20	3	308	26	0
524	1016	1	20	0	351	42	139	62	47	56	0	17	3	1	11	5	26	106	31	4	308	26	0
525	479	0	2	0	392	109	166	72	60	0	0	4	0	0	5	1	6	72	30	32	308	26	0
526	2841	125	0	0	805	67	148	153	168	206	0	0	0	166	0	68	38	262	20	16	308	26	1
527	0	0	0	0	0	0	0	0	0	0	27	0	0	55	0	21	1	11	0	4	308	26	0
528	1299	6	0	0	283	10	35	44	63	124	0	0	0	28	0	11	1	5	1	4	308	26	0
529	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	308	26	0
530	263	0	0	0	69	1	11	13	19	21	0	0	0	0	0	0	0	0	0	0	308	26	0
531	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	308	26	0
532	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	2	0	1	0	0	308	26	0
533	3469	909	24	2	890	15	216	181	69	236	0	15	1	0	0	0	2	60	3	0	309	26	1
534	1247	8	9	1	395	367	187	1	0	80	9125	1388	0	5	128	57	54	1442	766	26	309	26	1
535	2527	2395	213	2	45	12	7	6	12	8	262	0	73	0	0	0	7	52	40	2	309	26	2
536	4020	2	14	1	1485	16	224	247	450	195	66	0	0	0	0	0	1	29	34	6	309	26	1
537	0	0	270	26	0	0	0	0	0	0	0	2	7	0	5	0	28	0	32	0	309	26	0
538	3439	590	60	6	1025	8	147	193	356	107	398	10	1	0	1	0	6	107	26	34	309	26	1
539	655	22	0	0	162	20	22	28	29	54	0	31	0	354	55	73	241	227	232	10	301	25	0
540	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	8	9	15	19	8	301	25	2
541	8287	0	0	0	2773	380	683	525	498	483	0	4	0	11	101	1432	19	2063	257	626	301	25	2
542	2699	2	0	0	934	121	221	167	176	162	0	0	0	1	21	16	40	344	534	26	301	22	0
543	3338	4	0	0	1000	126	241	204	187	208	0	0	0	0	3	1	18	87	24	21	301	22	0
544	3681	4	0	0	1050	102	219	203	221	265	0	0	0	1	4	0	36	119	166	44	301	22	0
545	6921	0	0	0	2105	229	453	391	423	477	0	0	0	1	0	0	0	250	0	209	209	23	0
546	16834	0	0	0	5120	556	1102	950	1028	1159	0	1	0	6	48	5	35	1879	10	449	209	23	0
547	597	161	0	0	161	26	42	29	26	22	0	0	0	0	0	0	0	44	0	8	201	23	0
548	2103	6	0	0	560	48	107	107	125	164	0	16	0	7	33	120	64	424	107	20	202	23	0
549	588	0	0	0	188	31	52	37	35	33	0	2	0	0	18	1	238	1140	1044	234	202	23	0
550	3207	5	0	0	1049	156	271	201	194	184	0	0	0	0	0	0	0	139	0	9	202	23	0
551	5388	0	0	0	1792	235	467	310	295	335	0	0	0	0	0	0	4	113	2	56	202	23	2
552	6087	0	0	0	2275	419	580	450	401	277	0	0	0	7	19	13	12	28	8	35	202	23	0
553	1700	0	0	0	503	32	117	101	121	111	0	0	0	0	13	0	6	56	3	8	202	23	0
554	2475	0	0	0	912	152	219	188	186	107	0	0	0	2	52	9	36	124	106	15	202	23	0
555	3080	0	0	0	1210	278	428	180	116	124	0	5	0	3	40	19	35	265	83	66	202	23	0
556	2807	43	0	1	620	36	98	114	95	253	0	17	0	0	14	10	42	226	14	8	203	23	0
557	2153	12	0	0	445	0	7	73	145	214	0	0	0	0	7	0	17	140	7	14	203	23	0
558	4464	32	0	0	991	51	126	133	162	448	11	85	0	0	30	0	46	1002	58	8	203	23	0
559	329	33	0	0	52	38	52	13	0	12	1	5	0	2	0	2	7	54	14	2	203	23	2
560	329	33	0	0	53	39	53	13	0	13	3	20	0	10	0	10	31	218	56	11	203	23	2

YEAR 2030 ORTP DATA BY TAZ

TAZ	POP	GQ	HR	RC	HU	H1	H2	H3	H4	H5	J1	J2	J3	J4	J5	J6	J7	J8	J9	J10	DPSA	NB	MIL
561	3577	0	0	0	1381	30	115	173	380	234	77	0	0	0	0	0	7	20	3	3	203	23	1
562	1967	1	4	1	633	65	115	103	142	149	0	1	1	0	5	0	13	60	10	7	203	23	0
563	2977	37	0	1	825	48	140	155	214	228	0	31	0	0	44	22	84	550	301	11	203	23	0
564	5293	0	273	201	1935	352	553	357	311	249	0	0	0	0	0	0	0	0	0	0	203	23	0
565	5294	0	274	202	1935	353	553	358	311	249	49	0	238	7	75	5	55	790	32	387	204	23	0
566	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	204	23	0
567	2020	0	0	0	741	137	213	135	118	95	0	0	0	0	0	0	0	90	0	60	204	23	0
568	2740	4	0	0	699	59	135	130	123	228	0	25	0	1	13	0	13	363	3	18	201	23	0
569	3585	0	0	0	1070	81	170	182	245	281	0	6	0	3	49	17	47	895	9	73	201	23	0
570	558	0	0	0	164	8	33	32	40	40	0	0	0	1	19	0	3	154	1	20	201	23	0
571	1992	0	0	0	915	59	163	158	151	92	36	0	0	0	0	0	0	0	0	28	205	34	1
572	381	0	0	0	199	25	35	20	19	24	36	0	0	0	1	0	0	5	0	12	205	34	1
573	1142	0	0	0	597	74	104	61	57	71	36	0	0	0	8	0	0	36	0	35	205	34	1
574	1589	0	0	0	923	99	139	83	82	101	36	0	0	0	1	1	0	4	0	47	205	34	1
575	99	0	0	0	30	4	6	5	6	7	0	78	0	0	344	816	54	429	277	39	205	34	0
576	36	0	0	0	11	1	2	2	2	2	0	63	0	0	281	671	35	345	228	32	205	34	0
577	136	0	0	0	41	4	9	8	9	9	9	38	0	0	319	625	47	449	206	21	205	34	0
578	4041	0	0	0	1229	134	265	228	247	278	0	0	0	1	954	864	15	755	499	460	205	34	0
579	0	0	0	0	0	0	0	0	0	0	0	0	0	1	556	372	0	813	924	265	205	34	0
580	3284	0	0	0	999	109	215	185	201	226	0	6	0	0	430	362	14	385	242	218	205	23	0
581	1870	0	0	0	569	62	122	106	114	128	0	0	0	0	1	0	0	110	13	85	206	23	0
582	2203	0	4459	3279	672	74	146	124	134	151	4	0	2237	0	24	0	0	470	174	668	206	23	0
583	1502	0	1	0	761	167	223	110	79	41	0	0	0	0	1	0	0	126	366	63	206	23	0
584	2858	0	0	1	1449	319	425	210	149	78	0	0	0	0	0	33	0	120	0	109	206	34	0
585	2814	21	0	0	1402	301	439	183	134	85	0	0	0	0	0	0	0	85	0	91	206	34	0
586	1348	0	0	0	684	151	200	99	70	37	0	0	0	0	15	256	37	131	129	56	206	34	0
587	790	0	0	0	401	88	117	58	41	22	0	0	0	0	0	0	0	62	0	32	206	34	0
588	879	0	0	0	222	12	31	38	49	80	0	0	0	0	0	0	0	0	0	0	206	34	0
589	0	0	0	0	0	0	0	0	0	0	8	1	0	0	45	0	192	1083	1100	50	207	34	0
590	0	0	0	0	0	0	0	0	0	0	8	11	0	0	47	0	209	423	1183	51	207	34	0
591	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	208	34	0
592	318	0	0	0	87	8	18	17	19	24	9	15	0	0	15	0	73	94	86	38	207	34	0
593	0	0	0	0	0	0	0	0	0	0	9	3114	0	5	58	11	693	857	415	109	207	34	0
594	2591	0	0	0	712	66	143	135	158	195	0	3226	0	1	110	0	620	1387	530	364	207	34	0
595	7089	0	0	0	1949	181	391	369	432	534	0	0	0	0	0	0	0	143	0	875	207	34	0
596	0	0	0	0	0	0	0	0	0	0	0	1	0	0	28	0	117	577	414	24	207	34	0
597	1041	0	0	0	317	42	77	59	51	71	0	0	0	1	14	0	1	93	0	28	208	34	0
598	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	208	34	0
599	2173	0	0	0	615	38	122	113	164	161	0	0	0	0	0	0	0	0	0	17	208	34	0
600	1649	0	0	0	515	53	92	93	118	112	0	0	0	1	15	0	8	197	16	31	208	34	0
601	1649	0	0	0	516	53	93	93	118	113	0	0	0	2	16	0	8	198	16	32	208	34	0
602	3020	0	0	0	829	55	143	161	217	224	0	0	0	2	9	1	21	72	29	30	208	34	0
603	6921	0	0	0	2104	228	453	390	422	476	0	0	0	0	0	0	0	166	0	138	208	34	0
604	9530	0	0	0	2901	381	707	544	471	650	0	0	0	6	29	0	0	1262	0	260	208	34	0
605	2661	0	0	0	811	72	153	141	161	197	22	0	0	45	0	16	41	145	22	62	208	34	2
606	2014	0	0	0	554	38	96	108	145	150	0	0	0	3	9	1	21	72	30	31	208	34	0
607	2907	0	0	0	1135	266	297	185	164	124	0	2	0	7	6	2	38	200	145	238	210	34	0
608	1827	0	0	0	702	141	182	132	115	73	0	0	0	0	0	0	0	124	0	118	210	34	0
609	4243	0	0	0	1555	283	419	272	242	227	0	6	0	6	4	2	23	299	44	165	210	34	0
610	6990	20	0	0	1904	171	375	364	413	534	0	1	0	35	58	7	239	1505	580	664	210	34	0
611	2997	8	0	0	816	74	162	157	178	229	0	1	0	9	15	2	60	377	146	167	210	34	0
612	129	0	0	0	50	12	13	8	7	5	0	0	0	1	55	0	198	602	3000	35	210	34	0
613	2536	1	0	0	852	96	227	173	162	137	0	1	0	26	2	5	4	235	8	95	210	34	0
614	3806	3	0	0	1279	145	341	260	245	207	0	1	0	12	1	3	3	102	4	42	210	34	0
615	4258	0	0	0	1610	323	466	266	228	207	0	0	0	6	0	0	0	1089	0	231	210	34	0
616	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	210	34	0
617	74	0	0	0	22	0	5	5	2	7	0	8	0	116	25	24	92	54	53	1	210	24	0
618	371	0	0	0	116	5	32	23	29	19	0	5	0	71	9	14	24	298	28	47	210	34	0
619	3900	0	0	0	1032	93	176	151	163	391	0	3	0	37	5	1	5	233	1	104	801	34	0
620	56	0	0	0	46	0	2	1	6	4	16	0	0	0	0	0	0	0	0	0	803	24	1
621	2580	0	0	0	544	27	78	78	80	269	0	0	0	4	1	0	5	53	0	14	801	24	0
622	1639	1	0	0	332	21	45	46	46	168	0	80	0	0	5	1	12	516	3	7	801	24	0
623	2299	0	0	0	600	49	78	86	94	224	0	68	0	0	4	3	19	384	252	9	801	24	0
624	1878	13	0	0	476	39	82	69	67	177	0	3	0	5	3	1	3	86	35	3	801	24	0
625	231	0	0	0	49	1	7	7	7	23	0	6	0	125	11	24	4	88	31	1	801	24	0
626	2249	0	0	0	615	67	99	100	99	204	0	3	0	3	1	1	2	96	5	4	801	24	0
627	422	0	0	0	156	26	32	24	19	30	0	2	0	2	1	0	2	50	0	1	802	24	0
628	580	0	0	0	176	13	39	16	24	52	0	0	0	7	1	1	1	5	3	1	801	24	0
629	50	0	0	0	39	14	13	9	2	0	0	0	0	2	1	0	5	19	4	3	803	24	0
630	6	0	0	0	11	0	1	0	1	0	0	0	0	0	0	0	4	0	3	0	803	24	1

YEAR 2030 ORTP DATA BY TAZ

TAZ	POP	GQ	HR	RC	HU	H1	H2	H3	H4	H5	J1	J2	J3	J4	J5	J6	J7	J8	J9	J10	DPSA	NB	MIL
631	3377	0	3	2	1096	180	243	172	164	244	4	0	0	23	2	6	1	57	6	78	802	24	0
632	1882	0	10	7	598	88	136	100	92	137	0	2	0	13	17	4	45	671	8	50	802	24	0
633	1800	16	2	1	478	44	83	72	65	167	0	0	0	0	1	0	0	81	4	11	802	24	0
634	4650	189	7	45	1206	122	222	180	163	407	0	0	15	21	7	7	6	159	37	26	802	24	0
635	2723	98	1	1	906	152	261	164	124	140	0	17	0	185	19	34	23	352	47	21	804	24	2
636	2613	14	0	0	844	106	204	132	132	182	0	13	0	64	21	17	32	368	334	9	804	24	0
637	1617	0	0	0	638	142	121	85	62	115	0	100	0	54	38	4	51	701	369	4	804	24	2
638	2780	0	0	0	671	42	116	106	99	268	0	1	0	11	1	1	2	38	4	7	804	24	0
639	1360	0	1	1	369	24	58	44	66	130	0	50	0	5	7	0	4	377	4	1	804	24	0
640	2485	11	0	6	936	153	156	133	94	201	27	39	2	34	8	2	11	241	8	4	804	24	0
641	5966	114	0	111	2002	220	348	280	258	489	0	0	72	20	57	5	47	250	99	18	805	24	0
642	374	0	481	415	246	69	80	40	12	0	0	0	89	4	6	0	29	445	85	101	805	24	0
643	2428	0	0	348	1620	355	388	170	116	43	0	0	130	1	1	0	27	66	65	60	805	24	0
644	392	0	0	4	222	41	56	23	18	15	0	0	1	0	0	0	0	16	0	3	805	24	0
645	89	0	0	0	27	2	4	7	8	4	0	0	0	0	10	0	23	50	75	2	805	24	2
646	349	149	0	92	148	43	37	10	7	5	35	0	2	62	9	18	6	142	16	3	701	27	2
647	406	0	0	14	163	29	51	34	25	12	0	0	0	2	1	1	2	20	15	3	702	27	0
648	1509	3	0	17	831	189	277	126	92	4	36	0	0	14	2	4	2	24	5	13	701	27	0
649	877	5	0	4	236	34	47	44	30	77	0	0	0	0	1	0	1	40	9	3	702	27	0
650	971	1	0	9	341	61	90	53	52	60	0	0	0	103	5	30	18	166	36	2	702	27	0
651	1471	19	0	7	537	76	146	108	73	77	0	0	0	5	0	5	5	11	5	5	702	27	0
652	1363	0	0	0	383	23	89	75	58	114	0	1	0	8	5	13	2	13	25	6	703	27	0
653	1255	2	0	0	355	26	76	78	77	86	0	3	0	1	3	3	3	44	40	6	703	27	0
654	193	44	0	0	54	13	20	11	2	7	0	2	0	25	1	14	3	8	4	1	703	27	0
655	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	703	27	0
656	3216	160	0	9	1074	43	319	310	228	95	55	6	0	40	4	24	5	66	35	7	703	27	1
657	79	0	0	1	25	29	5	0	0	7	0	3	0	6	3	7	5	49	83	0	703	27	0
658	169	0	0	1	63	12	16	12	4	12	0	11	0	145	11	92	21	134	274	1	703	27	0
659	865	0	0	0	322	49	86	60	55	43	0	11	0	15	24	41	27	151	286	4	703	27	0
660	270	0	0	0	153	62	36	29	13	0	0	5	0	7	8	16	15	44	42	4	703	27	0
661	429	5	0	0	211	40	70	25	24	14	0	5	0	0	3	1	1	75	17	1	703	27	0
662	47	0	0	1	8	19	2	0	0	4	0	2	0	2	1	2	1	36	21	0	704	27	0
663	755	0	0	17	373	190	104	0	0	58	0	0	0	0	0	0	0	0	1	3	704	27	0
664	1973	8	0	220	829	170	270	133	91	83	0	2	1	26	33	53	15	84	168	50	705	27	0
665	2651	0	0	95	1158	214	300	191	147	113	0	2	5	4	12	11	2	121	23	25	705	27	0
666	1123	4	0	0	498	110	164	90	59	25	0	6	0	74	53	38	19	312	25	148	705	27	0
667	3777	132	1521	54	1386	236	287	156	143	280	33	51	394	257	50	14	74	1026	546	112	601	28	0
668	7576	550	279	10	2009	241	364	252	255	651	0	36	56	108	195	68	156	2139	568	76	602	28	0
669	3986	71	12	2	1533	288	341	177	136	280	0	48	3	86	23	19	33	375	95	24	603	28	0
670	1483	0	3	0	642	148	165	80	80	74	0	2	0	9	5	2	7	27	20	6	604	28	0
671	1034	0	0	0	350	51	92	54	53	66	0	11	0	75	26	9	3	135	31	22	501	29	0
672	185	0	0	0	71	12	20	14	9	10	0	0	0	1	0	0	0	10	0	4	501	29	0
673	1590	17	0	0	518	60	153	100	88	91	0	22	0	151	57	19	13	219	80	31	501	29	0
674	1800	0	0	0	619	75	174	131	113	96	0	4	0	109	19	10	2	41	14	47	501	29	0
675	334	0	0	0	108	15	29	17	21	20	0	0	0	5	5	0	0	11	0	5	501	29	0
676	1501	0	24	17	675	196	248	117	21	56	0	0	9	13	55	50	2	104	34	57	501	29	0
677	1061	0	6	5	354	76	92	56	40	71	0	0	0	1	2	2	1	20	1	21	501	29	0
678	342	0	7	5	139	44	37	16	9	20	0	0	0	10	16	0	1	32	1	24	501	29	0
679	92	0	6	5	36	9	14	6	3	5	0	0	0	0	0	0	2	60	3	0	502	13	0
680	1802	0	12	10	620	69	174	137	138	80	0	0	0	0	3	11	48	84	104	3	501	29	0
681	1976	0	5	4	595	60	153	119	132	119	0	0	0	1	0	0	1	15	1	13	501	29	0
682	2054	5	20	16	691	77	214	150	135	99	0	0	0	1	1	3	14	136	3	7	501	29	2
683	1085	0	6	5	355	32	117	61	85	53	0	0	0	1	0	1	1	17	1	10	501	29	0
684	4	0	9	7	2	0	2	0	0	0	22	0	0	0	0	0	1	0	1	0	502	30	2
685	764	0	19	15	322	55	142	60	30	21	0	0	0	1	0	0	3	19	2	19	502	30	0
686	663	0	4	3	217	14	75	38	47	34	0	0	0	0	0	0	1	15	0	2	502	30	0
687	853	0	3	1	326	47	138	65	39	27	0	5	1	2	9	14	2	87	12	6	502	30	0
688	76	0	0	0	61	20	34	17	0	0	0	0	0	0	0	0	0	6	0	1	502	30	0
689	751	0	1	1	254	27	98	51	34	41	0	0	0	0	1	0	0	5	0	1	502	30	0
690	691	0	0	0	190	12	51	29	40	53	0	7	0	0	4	0	1	138	0	1	502	30	0
691	892	7	1	1	287	26	101	61	49	45	0	3	0	0	3	3	8	35	3	2	502	30	0
692	1959	0	1	1	674	89	210	129	145	89	0	0	0	0	2	0	1	9	7	6	502	30	0
693	3177	0	1	1	1219	220	310	235	190	150	0	15	0	4	36	37	49	265	364	11	502	30	0
694	0	0	0	0	3	0	0	0	0	0	16	22	0	4	54	44	83	424	679	5	502	30	0
695	1745	14	1	1	819	224	342	109	63	43	11	20	0	2	23	20	49	276	157	6	502	30	0
696	696	0	2	2	312	73	124	51	27	14	0	1	0	0	4	0	2	25	1	3	502	30	0
697	1614	107	0	0	508	71	157	104	89	71	0	19	0	0	11	0	7	80	3	8	502	30	0
698	1337	96	0	0	357	33	68	70	85	88	0	105	0	0	41	0	27	487	24	7	502	30	0
699	1932	5	0	0	617	70	176	116	98	129	120	48	0	0	42	0	17	163	50	13	502	30	0
700	1609	16	0	0	553	69	124	95	93	103	0	12	0	0	11	4	2	151	223	23	502	30	0

YEAR 2030 ORTP DATA BY TAZ

TAZ	POP	GQ	HR	RC	HU	H1	H2	H3	H4	H5	J1	J2	J3	J4	J5	J6	J7	J8	J9	J10	DPSA	NB	MIL
701	382	0	0	0	153	19	63	32	18	12	0	1	0	0	1	0	0	23	0	18	502	30	0
702	126	0	0	0	37	2	10	7	10	7	0	119	0	0	45	41	11	920	78	3	502	30	0
703	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	2	4	0	502	30	0
704	577	2	0	0	195	29	63	37	33	29	0	8	0	0	0	0	0	165	0	1	502	30	0
705	1016	9	0	0	338	38	115	74	50	54	0	0	0	0	0	0	0	146	5	0	502	30	0
706	1617	10	0	0	536	94	157	98	99	84	0	0	0	1	6	0	0	15	0	7	502	30	0
707	6	0	0	0	3	0	0	2	0	0	0	0	0	0	0	0	1	0	1	0	502	30	0
708	0	0	0	0	0	0	0	0	0	0	0	7	0	35	0	5	6	60	101	13	502	30	0
709	2021	0	0	0	648	70	206	138	110	116	0	1	0	0	11	0	1	103	3	5	502	30	0
710	1246	0	0	0	465	81	163	96	70	49	0	3	0	0	64	17	9	143	73	17	502	30	0
711	1356	147	0	0	349	33	97	62	72	80	0	0	0	0	3	0	0	8	1	1	502	30	0
712	485	0	0	0	189	49	38	33	37	21	0	3	0	0	60	17	10	137	61	11	502	30	0
713	0	0	0	0	0	0	0	0	0	0	0	2	0	0	57	5	10	167	139	1	502	30	0
714	258	0	0	0	67	7	11	11	13	23	0	1	0	0	5	0	0	48	1	0	502	30	0
715	823	25	0	0	283	44	92	56	43	41	0	0	0	0	0	2	7	112	7	8	502	30	0
716	2506	0	0	0	829	115	245	160	146	137	38	0	0	1	0	9	31	801	275	32	502	30	0
717	693	28	0	0	231	39	74	41	29	38	0	6	0	0	26	26	18	121	31	6	502	30	0
718	1306	0	0	0	487	83	167	101	70	52	0	0	0	0	15	0	1	10	14	15	502	31	0
719	1684	0	0	0	735	165	287	113	91	43	0	4	0	0	16	3	2	89	40	14	502	30	0
720	3714	40	0	0	1368	239	462	252	201	159	0	287	0	25	63	12	20	564	94	34	502	31	0
721	3571	1836	0	0	643	216	191	66	46	114	0	2	0	1	8	0	37	32	15	10	505	31	1
722	7699	2496	0	0	1745	153	565	397	348	236	7007	735	0	5	133	63	101	527	396	10	505	31	1
723	485	0	13	9	184	24	74	28	30	21	0	12	1	23	49	75	73	263	129	34	503	31	0
724	987	0	0	0	303	22	83	73	59	61	202	0	0	0	3	11	13	140	39	2	503	31	0
725	1942	0	0	0	727	148	256	125	105	78	0	97	0	0	66	51	49	750	320	20	503	31	0
726	409	0	15	11	203	44	94	34	15	2	0	0	1	0	2	0	0	6	1	7	503	31	0
727	759	0	14	13	295	55	95	48	39	35	0	0	1	0	2	0	0	6	1	6	503	31	0
728	1054	26	20	16	405	88	125	58	58	49	0	10	1	1	22	3	3	520	4	7	503	31	0
729	933	0	25	17	378	68	121	74	49	36	0	2	1	0	9	1	2	143	27	6	503	31	0
730	1667	0	0	0	567	81	182	106	111	81	0	1	0	0	10	22	6	159	6	7	503	31	0
731	1516	0	0	0	541	99	180	109	68	73	0	10	0	1	8	16	6	73	4	11	503	31	0
732	2272	5	0	0	743	99	218	140	128	133	0	0	0	0	0	0	5	54	7	10	503	31	0
733	1765	9	0	0	750	153	275	136	94	47	11	0	0	1	6	57	43	271	424	20	503	31	0
734	2367	5	0	0	953	182	337	164	123	87	0	97	0	6	75	68	49	890	244	24	503	31	0
735	146	0	1	2	67	28	15	9	8	4	0	16	0	0	32	19	65	215	123	3	503	31	0
736	587	0	1	3	197	33	57	30	38	32	0	0	1	0	1	0	0	7	0	0	503	31	0
737	435	0	1	0	148	15	44	35	31	18	0	0	0	0	0	0	0	0	0	1	503	31	0
738	1238	5	6	4	427	57	134	80	78	60	0	2	0	0	21	14	26	126	138	13	503	31	0
739	3531	11	5	3	1137	127	370	238	165	211	4	1	0	1	12	9	16	81	83	30	503	31	0
740	1253	0	1	1	492	117	155	86	87	40	0	1	0	1	2	0	0	76	0	39	503	32	0
741	676	0	17	14	275	55	107	56	32	15	0	0	1	0	3	1	2	21	27	7	503	31	0
742	1685	0	15	12	782	161	276	125	79	47	0	0	2	1	31	22	43	278	91	28	503	31	0
743	2491	1	0	0	791	91	235	152	150	144	0	0	0	5	18	63	19	263	75	21	503	31	0
744	885	0	0	0	333	57	118	72	37	40	0	0	0	0	2	0	0	234	40	3	503	31	0
745	213	0	0	0	101	38	30	14	17	1	0	0	0	0	1	0	0	11	0	11	503	31	0
746	725	5	2	2	235	28	78	45	41	39	0	0	0	0	1	0	0	0	0	1	503	31	0
747	342	0	4	1	118	17	40	20	18	19	0	0	1	0	1	0	0	12	0	1	503	31	0
748	2693	0	7	4	1286	370	452	195	127	62	0	34	1	0	122	77	188	531	734	13	503	31	0
749	570	0	2	2	188	19	63	38	44	21	0	21	0	0	15	0	31	112	132	1	503	31	0
750	1388	328	10	10	332	36	84	81	73	54	0	91	0	12	40	9	1	244	31	4	503	31	0
751	1439	2	5	4	502	58	176	120	82	56	0	0	0	0	2	0	1	12	1	3	503	31	0
752	229	0	1	1	225	76	199	0	0	0	0	0	0	0	1	0	0	14	0	12	503	31	0
753	88	0	3	2	26	2	6	6	2	8	0	49	0	0	28	0	34	140	120	19	503	31	0
754	319	0	0	0	133	40	40	24	11	12	0	3	0	1	1	3	2	529	1	2	503	31	0
755	137	135	0	0	1	0	1	0	0	0	11	3	0	26	5	70	6	334	31	16	503	31	0
756	1872	7	0	0	706	129	254	130	103	70	0	1	0	2	2	4	4	157	5	7	503	31	0
757	1107	7	0	0	348	35	105	71	67	65	0	2	0	1	3	3	3	361	27	1	503	31	0
758	3937	5	0	0	1069	72	182	190	216	343	0	34	0	38	8	7	6	263	85	24	504	32	0
759	982	3	0	0	292	0	62	79	103	39	60	94	1	85	10	18	26	460	89	14	504	32	1
760	996	213	0	0	266	39	69	40	50	50	0	32	0	166	9	31	4	146	50	14	504	32	0
761	4367	0	0	0	1142	84	243	207	201	357	0	4	1	47	45	17	12	387	196	25	504	32	2
762	6	6	15	2	1	0	0	0	0	0	0	359	9	13	3779	526	187	1287	844	45	117	19	0

Honolulu High-Capacity Transit Corridor Project

Financial Analysis Methodology Report

June 30, 2006

Prepared for:
City and County of Honolulu

Prepared by:
Parsons Brinckerhoff Quade & Douglas, Inc.

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1.0 INTRODUCTION

The City and County of Honolulu (City), in cooperation with the Federal Transit Administration (FTA), has undertaken a study of high capacity transit service along a corridor between Kapolei and University of Hawai‘i at Mānoa. In preparing an Alternatives Analysis (AA) and the Draft Environmental Impact Statement (DEIS) for the Honolulu High-Capacity Transit Corridor Project, a methodology will be developed to evaluate the various alternatives for transit improvements in the corridor.

In evaluating alternatives being considered by the City, a series of methodology reports have been prepared that describe the analytical framework for evaluating specific issues. This report describes the methods, data sources, and format for reporting the results of a financial analysis of the No Build, Transportation System Management (TSM), and build alternatives that will be studied. The intended focus of this report is to:

Describe the process involved in conducting a financial condition and capacity analysis;
Identify the techniques, tools and procedures to be used in performing the analysis;
Identify the potential revenue sources and uses to be evaluated during the analysis; and
Describe the evaluation process and the purpose of sensitivity testing.

The financial analysis methodology report is designed to identify and document the steps, procedures, and tools to be used in conducting the financial analysis of the proposed alternatives. This document will be reviewed and approved by the City and the FTA prior to undertaking the financial analysis required in the alternatives analysis process.

The assessment of financial condition and capacity will require close interaction among the consultant team, the City, and local agencies involved in the financing planning process. For example, obtaining capital and operating cost estimates for the alternatives will require close coordination between Parsons Brinckerhoff, Lea+Elliott, Weslin Research and City staff to ensure that the estimates are accurate and reliable. Similarly, excise tax forecasts for the Island of O‘ahu will need to be reviewed by City staff. Concurrence from these agencies that the revenue forecasts are reasonable will be important to determining whether the City has the financial capacity to eventually build and operate a study alternative.

In conducting the financial analysis of the project alternatives, data and information will be collected from a number of different local and regional agencies and sources.

These will include:

- The City and County of Honolulu
- O‘ahu Metropolitan Planning Organization (OMPO)
- The State of Hawai‘i Department of Transportation (HDOT)
- Federal Transit Administration (FTA)

Local private companies and organizations such as commercial real estate brokers and private developers.

2.0 DESCRIPTION OF THE FINANCIAL PLANNING PROCESS

The financial planning process is part of a broader FTA transportation planning and project development process described in the *FTA Major Capital Investment Final Rule* issued December 7, 2000, which meets the statutory requirement of Title 49, USC Section 5309(e)(5).[1] This rule establishes the methodology by which FTA evaluates proposed "new starts" projects. Following these rules is required to maintain eligibility for capital investment grants and loans for "new starts" fixed guideway systems or extensions.

The FTA evaluation process culminates each year in an annual report submitted to Congress that includes a proposal on the allocation of amounts to be made available to finance grants and/or loans for capital projects for "new starts". Proposed "new starts" projects must receive FTA approval to advance from alternatives analysis to preliminary engineering and then from preliminary engineering to final design based largely on an evaluation of the proposed projects "new starts" criteria. There are three overall ratings that are assigned to each project: highly recommended, recommended, or not recommended based on the results of FTA's evaluation of each of the criteria for project justification and local financial commitment.[2]

Section 5309(e)(1)(c) requires that proposed projects be supported by an acceptable degree of local financial commitment, including evidence of stable and dependable financing sources to construct, maintain and operate the transit system. The evaluation considers Local Financial Commitment as measured by 1) the proposed share of the total project costs from sources other than Section 5309; 2) the strength of the proposed capital financing plan; and 3) the ability of the sponsoring agency to fund operation and maintenance of the entire system as planned once the guideway project is built. Each financial criterion is rated separately and a combined summary finance rating is developed for each project. Highly Recommended Projects must be rated at least "medium high" for finance and project justification; Recommended Projects must be rated at least "medium" for finance and project justification; and Not Recommended Projects are those that do meet the "medium" rating for either finance or project justification.

In the financial planning process for the project, the focus is on the two criteria that are rated by FTA in developing the summary finance rating: 1) stability and reliability of the proposed project's capital finance plan; and 2) the stability and reliability of the proposed project's operating finance plan. FTA gives particular emphasis to the capital finance plan by not allowing a "medium" summary finance rating if the capital plan does not make a "medium" rating. In addition to specifically rating

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[1] Additional FTA guidance can be found in a publication entitled Reporting Instructions for the Section 5309 New Starts Criteria, published by the Federal Transit Administration, July 2001. The agency also intends to publish a new document describing the program entitled policy and procedural guidance on the New Starts program, scheduled for release by FTA in the spring 2006.

[2] The Safe, Accountable, Flexible, Efficient Transportation Equity Act - A Legacy For Users (SAFETEA-LU), signed into law August 10, 2005, established a new project rating system: moves to the use of a five point rating system to evaluate and rate projects. FTA will continue to provide individual ratings for each of the criteria.

the capital plan, the overall financial rating also considers the non-Section 5309 share as well as the historic support of new start projects by the applicant.

In general, the financial planning process will consist of three principal types of activities. They are:

- Assessment of financial condition,
- Assessment of financial capacity, and
- Analysis of sensitivity tests.

The first two steps represent the components of the financial analysis required by FTA; the third step follows this analysis.[3]

2.1 ASSESSMENT OF FINANCIAL CONDITION

The evaluation of financial condition takes into account factors which may affect the ability of the City to operate, maintain, and make required investments in the existing transit system and the service it presently provides. Among the factors that must be considered in the financial condition analysis is the local economy. This analysis will review historical trends and forecasts of revenue as well as those economic variables that are primarily responsible for generating operating and capital revenues.

For example, the financial condition analysis will analyze historical trends and current forecasts for population, employment by sector, unemployment, construction, and general economic conditions in order to evaluate the reasonableness of current sales tax forecasts. An assessment of local economic trends is important because the local economy provides the basis for the local financial support extended to transit. Population growth and employment trends, by sector, are important because they underlie the generation of personal disposable income, taxable sales and generation of General Excise Tax (GET) revenues.

The financial condition analysis will also examine trends and projections for farebox and related operating revenues. Estimates for other operating revenues will be reviewed and evaluated to reflect existing and anticipated economic conditions, anticipated local polices and current City assumptions regarding receipt of federal and state financial assistance. For example, in the development of farebox revenues, we will utilize patronage estimates prepared by PB and fare policies provided by the City to estimate future annual fare revenues.

Once operating revenues have been estimated, operating costs for the committed levels of service by mode will be projected. For this analysis, rail and bus operating and maintenance (O&M) costs will be developed by Lea+Elliott and Weslin Research, respectively, and incorporated into the financial condition assessment. Since the financial condition analysis will only evaluate the City's ability to fund the continuation of existing and "committed" service, the projected O&M costs will represent

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[3] Guidance for Transit Financial Plans, published by the Federal Transit Administration, June 2000.

an extension of existing O&M costs factored by any increments of additional service that the City has made a financial commitment to initiate within the next several years.

The capital revenue and cost components to the financial condition assessment will reflect the needed rehabilitation and replacement costs required by the City's existing revenue and non-revenue vehicles, maintenance facilities, park-and-ride lots, transit centers, and equipment used in providing existing service.

Capital replacement costs will be forecast based on the City's existing vehicle inventory, age and policies regarding replacement. Capital revenues will be calculated based on expectations regarding FTA Sections 5307 and 5309 and other local sources available to meet capital requirements.

The operating cost and revenue data will be integrated into an annual cash flow statement of revenues and expenses that will determine end-of-year cash positions of the City for each year of the analysis. The cash flow analysis matches existing revenue sources with projected expenses and determines if deficiencies will exist. This is a year-by-year analysis that typically focuses on the following key data:

<u>Operating Cash Balances</u>. The accuracy of the year-to-year analysis will depend on a true estimate of available cash balances with which to initiate the operating and capital components of the cash flow analysis. Available cash must look at both committed and uncommitted cash and the committed revenues allocated to specific costs.

<u>Initial Year</u>. The initial year of the analysis should reflect audited financials from the previous fiscal year. For example, the first year in the cash flow should reflect FY 2005 actuals with the forecast beginning in FY 2006. The analysis will be structured to examine the effects on year-end cash position of changes in projected schedule, level of service, and alternative funding approaches.

To summarize, the objective of the analysis is to demonstrate that the City will have the financial capability to continue to provide the current level of service and maintain its capital plant in good working order.

An example of a cash flow statement for financial condition is included on the following page.

Baseline Operating Statement ($000's in Year-of-Expenditure)

SACRAMENTO RT																			11/11/2005
BASELINE ALTERNATIVE																			
FY 1993 - FY 2010																			
	FY 1993	**FY 1994**	**FY 1995**	**FY 1996**	**FY 1997**	**FY 1998**	**FY 1999**	**FY 2000**	**FY 2001**	**FY 2002**	**FY 2003**	**FY 2004**	**FY 2005**	**FY 2006**	**FY 2007**	**FY 2008**	**FY 2009**	**FY 2010**	**TOTAL**
Annual CPI	3.20%	3.60%	4.00%	4.20%	4.60%	4.50%	4.30%	4.30%	4.30%	4.20%	4.40%	4.50%	4.20%	4.20%	4.20%	4.20%	4.20%	3.50%	**'94-10**
Conversion Factor from 1993 $	1.00	1.04	1.08	1.12	1.17	1.23	1.28	1.33	1.39	1.45	1.51	1.58	1.65	1.72	1.79	1.87	1.94	2.01	
Beg. Cash Balance (Operations)	$1,572	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
REVENUES																			
Local																			
Passenger Fares	13,531	14,984	15,664	16,374	17,698	18,501	19,340	20,217	21,134	22,092	23,094	24,141	27,091	28,320	29,604	30,947	32,350	33,817	395,368
Measure A (1/6 cent sales tax)	16,939	17,714	18,511	19,713	21,046	22,457	23,888	25,420	27,079	28,807	30,691	32,717	34,762	37,196	39,774	42,476	45,361	48,415	516,027
LTF (1/4 cent sales tax)	21,404	21,203	21,750	23,595	25,192	26,880	28,593	30,426	32,413	34,481	36,736	39,160	41,609	44,522	47,607	50,840	54,295	57,950	617,252
Advertising, Interest & Other	800	600	300	337	352	368	384	400	418	435	454	475	495	516	537	560	583	604	7,818
Other (AQMD)		200	200	200	200	200													1,000
State																			
STA	1,612																		0
Federal																			
Section 8	75	60	60	50	60	60	60	60	60	70	70	70	70	70	80	80	80	80	1,140
Section 9 - Operations	3,450	3,450	3,450	3,450	3,450	4,160	4,160	4,160	4,160	4,160	4,160	5,110	5,110	5,110	5,110	5,110	5,110	6,280	75,700
Sub-Total	57,811	58,211	59,935	63,719	67,999	72,626	76,425	80,683	85,263	90,045	95,205	101,673	109,137	115,733	122,712	130,013	137,779	147,146	1,614,305
EXPENSES																			
Bus O & M	37,033	38,954	39,420	41,340	43,242	48,236	50,310	52,474	54,730	57,029	59,538	62,217	64,830	71,823	74,839	77,983	81,258	84,102	1,002,325
LRT O & M	13,954	14,835	15,235	17,103	17,890	18,695	19,499	20,337	21,212	22,103	23,075	24,114	25,127	26,182	27,281	28,427	29,621	30,658	381,395
Other O & M	0	0	345	359	376	393	410	427	446	464	485	507	528	550	573	597	622	644	7,725
Americans With Disabilities Act	961	1,450	2,500	3,400	4,800	6,147	6,411	6,687	6,974	7,267	7,587	7,928	8,261	8,608	8,970	9,347	9,739	10,080	116,156
Sub-Total	51,948	55,239	57,500	62,203	66,307	73,471	76,630	79,925	83,362	86,863	90,685	94,766	98,746	107,163	111,664	116,354	121,241	125,484	1,507,601
Annual Surplus (Deficit) Oper.	5,863	2,972	2,435	1,516	1,691	-845	-205	758	1,902	3,182	4,520	6,907	10,391	8,570	11,049	13,659	16,539	21,662	
Cumul. Surplus (Deficit) Oper.	7,435	2,972	2,435	1,516	1,691	-845	-205	758	1,902	3,182	4,520	6,907	10,391	8,570	11,049	13,659	16,539	21,662	106,704
5% Annual Operating Reserve (1)	0	0	0	1,516	3,207	2,363	2,158	2,916	4,168	4,343	4,534	4,738	4,937	5,358	5,583	5,818	6,062	6,274	
Operating Balance After Reserve	7,435	2,972	2,435	0	-1,516	-3,207	-2,363	-2,158	-2,267	-1,161	-14	2,169	5,454	3,212	5,465	7,841	10,477	15,388	
Addition of Previous Year Reserve	0	0	0	0	1,516	3,207	2,363	2,158	2,916	4,168	4,343	4,534	4,738	4,937	5,358	5,583	5,818	6,062	
Transfers to Capital	$7,435	$2,972	$2,435	$0	($0)	$0	($0)	($0)	$650	$3,007	$4,329	$6,703	$10,192	$8,150	$10,824	$13,424	$16,295	$21,450	$100,430

(1) While it is desirable to always maintain a 5% annual operating reserve, in those years when a shortfall occurs and an operating reserve exists, the reserve has been reduced to minimize or eliminate the deficit.

FIGURE 1 -- CASH FLOW STATEMENT SHOWING FINANCIAL CONDITION

2.2 ASSESSMENT OF FINANCIAL CAPACITY

Financial capacity, as used in this context, refers to the ability of the City to fund and/or finance future operating and capital requirements, which assume that the Locally Preferred Alternative (LPA) is built and placed in operation.

Financial capacity analysis compliments the financial condition assessment, which evaluates the City's ability to finance its existing service. Therefore, financial capacity primarily focuses on the incremental costs and revenues, both capital and operating, associated with the Baseline and LPA alternatives. However, financial capacity must also examine how the City's current bus system, and the costs associated with its operations, may be modified by implementing any of the alternatives in this corridor. For example, existing bus service might be reduced in the corridor but then redeployed to other areas in need of new or augmented service. As a result, the financial capacity analysis must consider how previous baseline assumptions and service parameters might change, given the assumption that the City would be implementing any alternative.

In virtually all respects, the financial analysis process used in assessing financial capacity is identical to that used in evaluating financial condition. The additional analysis focuses on the following new or incremental data items:

- Construction costs and schedules,
- Operating and maintenance costs associated with the selected alternative,
- Capital revenues and financing techniques to be issued, and
- Cash flow statement – financial condition. Operating and maintenance sources of revenues used to meet O&M costs associated with the additional service.

An example of a cash flow model run examining financial capacity is included on the following page.

2.3 CONSTRUCTION COSTS AND SCHEDULES

The capacity analysis must include the annual costs associated with implementing the LPA and procuring sufficient vehicles necessary to operate the service. Vehicle procurement may also include additional buses needed to "feed" the additional rail stations.

Capital costs typically include an implementation plan or program by year, which identifies the following cost components:

- Right-of-way acquisition,
- Preliminary Engineering and Final Design,
- Construction,
- Vehicles,
- Start-up costs (training, pre-revenue service, etc.),
- Construction management and oversight, and
- Contingency and insurance.

Alternative 7B -- LRT High - UPRR Alignment to Elk Grove/Grant Line Road

Capital Statement and Combined Cash Position ($000's in Year-of-Expenditure)

SACRAMENTO RT																			11/11/2005
ALTERNATIVE 7B -- LRT HIGH																			
FY 1993 - FY 2010																			
	FY 1993	**FY 1994**	**FY 1995**	**FY 1996**	**FY 1997**	**FY 1998**	**FY 1999**	**FY 2000**	**FY 2001**	**FY 2002**	**FY 2003**	**FY 2004**	**FY 2005**	**FY 2006**	**FY 2007**	**FY 2008**	**FY 2009**	**FY 2010**	**TOTAL**
Annual CPI	3.20%	3.60%	4.00%	4.20%	4.60%	4.50%	4.30%	4.30%	4.30%	4.20%	4.40%	4.50%	4.20%	4.20%	4.20%	4.20%	4.20%	3.50%	**'94-10**
CPI Conversion Factor from 1993 $	1.00	1.04	1.08	1.12	1.17	1.23	1.28	1.33	1.39	1.45	1.51	1.58	1.65	1.72	1.79	1.87	1.94	2.01	
Annual Inflation (Construction)	4.50%	4.50%	4.50%	4.50%	4.50%	4.50%	4.50%	4.50%	4.50%	4.50%	4.50%	4.50%	4.50%	4.50%	4.50%	4.50%	4.50%	4.50%	
Constr. Conversion Factor from '93$	1.00	1.05	1.09	1.14	1.19	1.25	1.30	1.36	1.42	1.49	1.55	1.62	1.70	1.77	1.85	1.94	2.02	2.11	
BEG. CASH BALANCE (CAP'L)	$0	$0	$4,123	$3,853	$3,206	$13,524	$52,007	$92,992	$146,461	$210,272	$200,046	$113,631	$43,317	$10,006	($47,082)	($149,867)	($223,080)	($175,781)	
TRANSFERS FROM OPER'S	9,752	2,962	2,425	0	44,489	50,331	55,042	59,810	52,680	36,974	13,318	0	0	3,293	12,983	24,362	0	0	358,670
REVENUES																			
Local																			
New State Gas Tax (Assumed)	0	0	0	3,600	7,140	10,700	14,290	17,860	21,430	25,000	28,570	32,140	35,710	39,290	42,860	46,430	50,000	53,570	428,590
Measure A (1/6 cent sales tax)																			
County Developer Fees		2,000	2,080	2,167	2,267	2,369	2,471	2,577	2,688	2,801	2,924	3,056	3,184	3,318	3,457	3,602	3,754	3,885	48,601
Tax Increment Bond Proceeds						1,371													1,371
Private Sector Financing of LRV's						1,022	1,168	1,241	0	1,219	1,273	1,331		1,453	1,519	1,587			11,832
State																			
STA				1,433	1,515	1,602	1,688	1,779	1,877	1,978	2,088	2,205	2,321	2,460	2,606	2,757	2,916	3063	32,288
Prop 108									19,250	19,250	19,250	19,250	19,250	19,250	19,250	19,250			154,000
Prop 116			6,000	6,000					11,000	11,000	11,000	11,000	11,000	11,000	11,000	11,000			100,000
FCR						4,770	6,360	4,770											15,900
TCI		1,554	1,616	1,684	1,762	1,841	1,920	2,002	2,089	2,176	2,272	2,374	2,474	2,578	2,686	2,799	2,917	3,019	37,763
Federal																			
Section 3 -- New Starts	1,000	8,900	0	0	73,169	71,429	72,669	71,528	73,426	71,909	70,115	41,766	34,761	35,293	36,864	37,773	6,155	6,371	712,128
Section 3 -- Bus Capital	0	392	1,826	9,307	8,042	4,206	12,839	3,205	3,344	22,757	3,640	3,804	45,749	4,134	6,711	19,550	21,467	4,855	175,829
Section 3 -- Rail Mod	0	1,200	1,200	1,200	1,200	1,242	1,242	1,242	1,242	1,242	1,242	1,285	1,285	1,285	1,285	1,285	1,285	1,330	21,295
Section 9 - Capital	4,900	4,900	4,900	4,900	4,900	5,820	5,820	5,820	5,820	5,820	5,820	7,154	7,154	7,154	7,154	7,154	7,154	8,794	106,235
STP/CMAQ	0	4,000	4,000	4,000	4,000	4,909	4,909	4,909	4,909	4,909	4,909	6,331	6,331	6,331	6,331	6,331	6,331	8,050	91,490
Sub-Total	5,900	22,946	21,622	34,291	103,994	111,280	125,395	116,933	147,074	170,060	153,103	131,696	169,220	133,546	141,724	159,519	101,960	92,937	1,937,321
EXPENDITURES																			
Administration Building					5,000														5,000
Lease Payments		4,603	4,475	4,340	4,198	4,049	3,893	3,731	3,563	3,389	3,217	3,044	2,872						45,374
Miscellaneous		488	507	528	553	577	602	628	655	683	713	745	776	809	843	878	915	947	11,847
Bus																			
Bus Additions and Replacements	32,851	0	1,888	11,838	10,126	0	0	0	0	25,695	0	0	95,098	39,802	44,796	62,564	22,379	0	314,186
Baseline Bus Facilities	0	523	546	571	596	5,608	13,674	680	711	743	776	811	848	886	926	968	1,011	1,057	30,935
Corridor Bus Improvements		0	0	0	6,635	6,934	7,232	7,543	7,867	8,197	8,558	8,943	9,319	9,710	10,118	10,543	10,986	11,370	123,955
Non-Corridor Bus Improvements		0	0	0	0	0	3,445	3,593	3,748	3,905	4,077	4,260	4,439	4,626	4,820	5,023	5,234	5,417	52,587
Rail																			
LRV's						25,547	29,692	31,028	0	30,465	31,836	33,268	0	36,330	37,965	39,673	0	0	295,803
Yards and Shops (Excluding So. Corridor)										7,616	7,082	7,400	0	9,083	8,445	8,825	0	0	48,451
LRT Extension to Intermodal Terminal		0	0	0	0	7,178	10,001	7,839	0	0	0	0	0	0	0	0	0	0	25,018
South Corridor					92,601	64,512	61,797	58,708	92,024	89,754	87,094	49,007							595,498
Sunrise/Gold River Extension		0	0	0	0	0	0	0	17,421	36,409	76,096	59,640	0	0	0	0	0	0	189,565
Hazel Avenue		0	0	0	0	0	0	0	0	0	22,518	23,531	24,590	0	0	0	0	0	70,640
Antelope Extension		0	0	0	0	0	0	0	0	0	0	0	24,183	50,543	105,635	82,791	0	0	263,153
ETB Demonstration Project	0	0	0	0	0	0	0	0	0	0	0	0	28,534	29,732	30,981	32,282	0	0	121,529
Planned Additions to Existing LRT		8,857	9,256	9,673	10,108														37,894
Other Rail Support	7,000	7,315	7,644	7,988	8,348	8,723	9,116	9,526	9,955	10,403	10,871	11,360	11,871	12,405	12,964	13,547	14,157	14,794	180,986
Sub-Total	39,851	21,786	24,316	34,938	138,165	123,128	139,452	123,275	135,944	217,259	252,837	202,010	202,531	193,927	257,492	257,094	54,681	33,585	2,412,420
Annual Surplus (Deficit) Capital	-33,951	1,160	-2,695	-647	-34,171	-11,848	-14,057	-6,342	11,131	-47,199	-99,733	-70,314	-33,311	-60,381	-115,768	-97,576	47,299	59,352	
COMBINED CUMUL. SURPLUS (DEFICIT)	0	4,123	3,853	3,206	13,524	52,007	92,992	146,461	210,272	200,046	113,631	43,317	10,006	-47,082	-149,867	-223,080	-175,781	-116,429	-116,429
Local Match Requirement	$0	$7,423	$13,918	$16,431	$103,868	$107,413	$121,643	$106,530	$136,246	$140,651	$131,838	$95,704	$100,298	$87,083	$89,985	$95,422	$23,597	$20,331	1,398,381

FIGURE 2 -- CASH FLOW STATEMENT SHOWING FINANCIAL CAPACITY

Capital costs will be estimated in constant year 2006 dollars. Cost escalation rates will be used that reflect the expected escalation rate of various capital components. For example, right-of-way costs typically escalate at a higher rate (8-12 percent) than do construction costs (4-6 percent). However, economic factors influence these rates dramatically, and local Honolulu market conditions will be reflected in these rates.

Beyond new construction and vehicle acquisition costs, capital rehabilitation and replacement costs will also be projected in the financial capacity analysis. These projections will be based on a comprehensive inventory of fixed assets and applying City and transit industry experience regarding the routine level of reinvestment necessary to maintain structures and equipment in a state of good repair.

2.4 OPERATING AND MAINTENANCE COSTS

Financial capacity assessment must include projections of annual system-wide operating and maintenance (O&M) costs. Particular attention will be given to any increase (or decrease) in operating and maintenance costs resulting from major capital investments, such as implementing an LPA. The O&M cost estimates are based on service and maintenance plans described in the final definition of alternatives for each transit alternative. The approach for developing these estimates is provided by Lea+Elliott and Weslin Research. For financial analysis purposes, forecast year annual O&M costs will calculated in constant year 2006 dollars. Current year estimates will be adjusted in the costing analysis for any real increases due to inflation.

2.5 CAPITAL REVENUES AND FINANCING TECHNIQUES

Funding the capital costs associated with building the TSM or fixed guideway alternatives will come largely from local sources such as the recently adopted ½-cent GET surcharge[4], redevelopment-generated tax increment, and developer fees; federal Section 5309 Discretionary Funds and other SAFETEA-LU funding sources; and new sources such as benefit assessment and public-private venture combinations. Many of these sources are discussed in Section 4.0 of this report.

The analysis will rely on certain assumptions regarding the level of federal participation in the project. The financial capacity assessment will evaluate, through sensitivity testing, various levels of federal participation. For example, while initial analyses might assume a 50 percent federal participation, alternative scenarios could assume 60 percent and 30 percent.

If the capacity assessment requires it, our cash flow analyses will assume a bonding program provided that sufficient amounts and types of revenue are available to provide adequate credit to support a financing. An effective bonding program will probably require use of a significant portion

[4] The ½ -cent GET surcharge was approved by the City and County of Honolulu City Council on August 23, 2005. The new ordinance, #05-027, authorizes the collection of the Excise and Use Tax Surcharge for up to 15 years, beginning January 1, 2007.

of the new GET for leveraging purposes. The assessment will develop the most advantageous financing strategy consistent with financing needs (capital deficits that cannot be covered through pay-as-you-go), credit sources adequate to support the needed financing, and balancing the costs of borrowing against construction cost increases over time.

2.6 OPERATING AND MAINTENANCE REVENUES

Revenue sources which can be used for operating and maintenance support are presented and discussed in Section 4.0. However, in general, they consist of fare revenues, advertising and concession revenues, general fund revenues, and other local sources such as excise tax revenues and other sources generated from local assessments and contributions. O&M revenue sources must support not only the LPA, but an expanded local bus system as well.

2.7 ANALYSIS OF SENSITIVITY TESTS

Sensitivity testing is a critical step in the financial capacity analysis. It is an acknowledgment of the uncertainty in the cost and revenue estimates produced at the alternatives analysis state of project development. As a result, sensitivity tests are made of the key variables for the expense and revenue forecasts; financing assumptions; and inflation to estimate how changes in their behavior affect financial capacity.

Candidates for sensitivity tests will include:

- Construction costs, contingency factors and escalation rates;
- Construction schedules;
- Operating cost increases;
- Various levels of federal participation;
- Local sources of revenue; and
- Fare revenues which reflect various ridership levels and fare policies.

Once the ranges in the different variables have been selected, each one will be tested in the cash flow model to determine what effect the change (positive or negative) will have on the ending cash balances on the scenario.

3.0 TECHNIQUES TO BE USED IN THE FINANCIAL PLANNING PROCESS

To support the financial planning process and applications described in the previous sections, we will primarily use spreadsheet programs, potentially augmented with some specific financial models, to complete the analyses and assessments.

3.1 SPREADSHEET MODEL

The cash flow models used to assess both financial condition and capacity will use a spreadsheet program, most likely Excel. This package has been used on numerous cash flow models to examine financial capacity previously and has existing templates for ready use in this effort.

In addition, presentation graphics prepared from Excel will be used consisting of bar graphs, line graphs and other charts to enhance the communication of financial and performance data.

3.2 FINANCIAL MODELS

In certain circumstances, other forms of spreadsheet applications will be used to provide specific financial analysis that supports the cash flow program. For example, we will likely prepare fare revenue calculations based on an independent financial model application. In this independent model, we will enter annual patronage estimates for the Baseline, enhanced bus, and rail alternatives. These patronage (systemwide) estimates will be multiplied by average annual fares in order to calculate total fare revenues.

In a similar manner, annual rehabilitation and replacement costs can be determined based on replacement cost estimates (by bus), and on annual rehabilitation costs. These estimates, in turn, depend on variables (costs, depreciation schedules, etc.), which lend themselves to an independent financial model application.

The use of financial and spreadsheet models is useful in capacity analysis because they can easily support "what if" analyses and other analysis such as sensitivity testing. "What if" analyses evaluate the effects of varying certain operating or capital cost and revenue assumptions that generally fall within the control of the transit operator. Examples include wage and salary growth, fringe benefit growth, or changes in service parameters such as vehicle service hours or miles. The evaluations examine the impact of varying assumptions on ending cash balances. "What if" analyses may be considered a part of any ongoing work connected with evaluating future cost and revenue projections. Sensitivity testing, on the other hand, involves the selection of certain variables that are typically outside the control of the transit operator, such as rates of inflation, sales tax growth or construction schedule delays, and evaluating the impact of changes in these variables.

4.0 IDENTIFICATION OF EXISTING AND POTENTIAL REVENUE SOURCES

A component of this Financial Analysis Methodology Report is the identification of potential revenue sources that may be used to meet anticipated capital and operating costs associated with the existing system and future system expansion. These sources will be used as the starting point for analysis; however, additional innovative sources may be identified as the analysis progresses. The following discussion identifies and evaluates existing federal, state and local sources that may be used in the condition and capacity analyses.

The identification of funding sources will be divided into two areas of consideration: a) existing federal, state and local sources; and b) potential sources of revenue. This section also identifies major data sources to be used in the Financial Analysis and how they will be used in the analysis process.

4.1 EXISTING SOURCES OF FUNDS

The financial evaluation will review all existing sources of funds currently available to the City. This review will address the following issues by funding source:

- How much funding is available from each revenue source and how can the funding be used (e.g., capital improvements only, both capital and operating, etc.)?
- What is the likelihood that these funds will be on-going and at what levels?
- How can the City increase its share of this particular revenue source?

Individual approaches to assessing these funds will vary based on funding source type. Analysis techniques will include contacts with Congressional appropriations committees, contacts at individual federal and state offices, and independent analyses of the trends of individual funding sources, i.e., inflation rates, excise tax and property tax projections.

An overview of the existing funding sources to be analyzed follows by source type.

4.1.1 Federal Funding Sources

In August 2005, the President signed into law the Safe, Accountable, Flexible, and Efficient Transportation Equity Act - A Legacy for Users (SAFETEA-LU). This successor to TEA-21 provides $286.4 billion in guaranteed funding for federal surface transportation programs over six years through FY 2009, including $52.6 billion for federal transit programs, a 46% increase over transit funding provided under the previous funding cycle. SAFETEA-LU builds on the success of the two previous surface transportation authorization statutes. The analysis will examine the potential for this federal program and potential funding levels.

In developing the analysis of available federal funds, it is assumed that funding will be available for the next two fiscal years based on the City's budget projections. Beyond 2005, it is assumed that formula funds contained in the federal transportation act reauthorization will grow at rates estimated by City staff and the consultant team. For FY 2005, the State of Hawai'i received $56.7 million in FTA funding. Discretionary monies will be analyzed separately based on the projected earmarks that will be determined via an interview of appropriate City staff. The following federal sources will be analyzed as part of the financial planning process.

FTA Section 5307 Urbanized Area Formula Funds (49 U.S.C.)

FTA Section 5307 Urbanized Area Formula Grants are based upon population, levels of service and ridership. For the City, the federal transportation act limits the application of these formula grants to capital and planning purposes. However, preventive maintenance expenses are considered "capital" under this program. Table 1 summarizes the FTA Section 5307 formula funds allocated to the City between fiscal years 2000 and 2004.

Table 1: FTA Section 5307 Funding Allocated to Honolulu (Millions $)

	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004
FTA Section 5307	$23.9	$22.8	$24.6	$27.8	$19.8

Source: Federal Transit Administration

Table 2 summarizes the FTA Section 5307 apportionments and estimated apportionments to the City between fiscal years 2005 and 2009, per SAFETEA-LU.

Table 2: FTA Section 5307 Funding Allocated to Honolulu (Millions $)

	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009
FTA Section 5307	$27.0	$26.3	$27.3	$29.6	$31.5

Source: Federal Transit Administration

FTA Section 5309 Capital Investment Program Funds

FTA Section 5309 Capital Investment Program provides funds for transit capital projects that meet specific criteria either by allocation where the project is named or by apportionment under a funding formula. Under FTA Section 5309, such projects include the New Starts, Fixed Guideway Modernization, and the Bus and Bus Facilities Discretionary programs. On a national level, the program is currently funded at approximately $3.7 billion per year for all competing national projects. A summary of FTA Section 5309 funds apportioned and allocated over a five year period to the City is presented in Table 3.

Table 3: FTA Section 5309 Funding Apportioned and Allocated to Honolulu (Millions $)

	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004
Bus and Bus Facility Discretionary	$2.0	$5.9	$9.7	$13.5	$9.6
Fixed Guideway Modernization	$0.6	$0.9	$1.1	$1.1	$0.8
New Starts		$2.5	$11.9		
Total Funds	$2.6	$9.3	$22.6	$14.7	$10.4

Source: Federal Transit Administration

Table 4 summarizes the FTA Section 5309 apportionments, allocations, estimated apportionments, and estimated allocations to the City between fiscal years 2005 and 2009, per SAFETEA-LU.

Table 4: FTA Section 5309 Funding Apportioned and Allocated to Honolulu (Millions $)

	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009
Bus and Bus Facility Discretionary	$11.2	$1.4	$1.3	$1.3	$1.3
Fixed Guideway Modernization	$1.1	$1.4	$1.5	$1.7	$1.9
Total Funds	$9.3	$2.7	$2.8	$3.0	$3.2

Source: Federal Transit Administration

FTA Section 5309 New Starts funding is allocated on a project basis for major fixed guideway investments following the completion of the FTA New Starts and Planning and Project Development Process. The analysis will review recent federal rail commitments and "earmarks" to evaluate the likelihood of high federal participation, given intense national competition for limited rail funding. In addition, the analysis will also evaluate the length of the payment schedule–i.e., number of fiscal years–that other transit properties have had to wait to receive all of their approved FTA Section 5309 funding.

The New Starts program under the federal reauthorization legislation, SAFETEA-LU, has a five level rating system for projects: High, Medium High, Medium, Medium-Low, and Low. The project justification criteria also include economic development and land use. FTA looks favorably upon projects cited in corridors with high densities. This rationale is based upon the fact that the more people who live, work, and study in close proximity to public transit stations, the greater the likelihood that they would use transit. Corridor-level thresholds to quantify appropriate minimum levels of development around transit stations along new transit corridors could be established as part of any transit extension plan. This greatly enhances efforts to secure FTA Section 5309 New Start funding.

FHWA Flex Funds

Flexible funds are certain legislatively specified funds that may be used either for transit or highway purposes. The idea of flexible funds is that a local area can choose to use certain Federal surface transportation funds based on local planning priorities, not on a restrictive definition of program eligibility. Flexible funds include Federal Highway Administration (FHWA) Surface Transportation Program (STP) funds and Congestion Mitigation and Air Quality Improvement Program (CMAQ) and Federal Transit Administration (FTA) Urban Formula Funds.

Since the enactment of ISTEA, FHWA funds transferred to the FTA have provided a substantial new source of funds for transit projects. When FHWA funds are transferred to FTA, they can be used for a variety of transit improvements such as new fixed guideway projects, bus purchases, construction and rehabilitation of rail stations, maintenance facility construction and renovations, alternatively-fueled bus purchases, bus transfer facilities, multimodal transportation centers, and advanced technology fare collection systems. Once they are transferred to FTA for a transit project, the funds are administered as FTA funds and take on all the requirements of the FTA program. Transferred funds may use the same non-Federal matching share that the funds would have if they were used for highway purposes and administered by FHWA.

The Surface Transportation Program (STP) (23 U.S.C. 133) provides the greatest flexibility in the use of funds. These funds may be used (as capital funding) for public transportation capital improvements, car and vanpool projects, fringe and corridor parking facilities, bicycle and pedestrian facilities, and intercity or intracity bus terminals and bus facilities.

The Congestion Mitigation and Air Quality Improvement Program (CMAQ) (23 U.S.C. 149) has the objective of improving the Nation's air quality and managing traffic congestion. CMAQ projects and programs are often innovative solutions to common mobility problems and are driven by Clean Air Act mandates to attain national ambient air quality standards. Eligible activities under CMAQ include transit system capital expansion and improvements that are projected to realize an increase in ridership; travel demand management strategies and shared ride services; pedestrian and bicycle facilities and promotional activities that encourage bicycle commuting. Programs and projects are funded in air quality nonattainment and maintenance areas for ozone, carbon monoxide (CO), and small particulate matter (PM-10) that reduce transportation-related emissions.

The National Highway System (NHS), established in 1995, provides funding for a wide range of transportation activities (23 U.S.C. 103(b)). Eligible transit projects under the NHS program include fringe and corridor parking facilities, bicycle and pedestrian facilities, carpool and vanpool projects, and public transportation facilities in NHS corridors, where they would be cost effective and improve the level of service on a particular NHS limited access facility.

The allocation of Federal highway funds within Hawai'i is administered by the Hawai'i Department of Transportation. The use of Federal highway funds for the Honolulu High-Capacity Transit Corridor Project could occur as an action by HDOT.

Innovative Financing Mechanisms

Non-traditional financing tools are available through Federal law and programs. These tools, such as the Transportation Infrastructure Financing Innovation Act (TIFIA) program, can supplement traditional financing tools. They will be evaluated for their potential application on this project.

4.1.2 Local Funding Sources

Farebox Revenues

In 2003, the City increased passenger fares for riding TheBus. Pursuant to Ordinance 03-27, the City has adopted a policy that requires the bus farebox recovery ratio not fall below 27 percent nor exceed 33 percent. In 2003, farebox revenues totaled $31.6 million, representing 23% farebox recovery. The current fare structure is presented in Table 5.

Table 5: TheBus Fare Structure

Fare Category	Fare	Monthly Pass
Adult	$2.00	$40.00
Youth	$1.00*	$20.00
Senior Citizen	$1.00*	$30.00**
Disabled	$1.00*	$30.00**

* Fare applicable with $10 Reduced Fare Card or valid Medicare Card **Cost for annual pass
Source: TheBus, 2005

City General Fund and Highway Fund

City funding of transit operations and maintenance comes from the General Fund and the Highway Fund. The City and County General Fund includes a variety of revenue sources, with the largest being property taxes. The City and County Highway Fund includes three major revenue sources: the County fuel tax; the County motor vehicle weight tax; and the public utility franchise tax. Portions of both the City and County General Fund and the City and to be used for transit operations and maintenance.

Revenues from the City and County General Fund and the City and County Highway Fund are also used to pay debt service on bonds. Capital projects are funded from the bond proceeds. Most surface transportation capital projects receive their local funding from the City and County Highway Improvement Bond Fund; some projects also receive funding from the City and County General Improvement Bond Fund or the City and County Capital Projects Fund.

Table 6 shows General Fund and Highway Fund revenues between fiscal year 2001 and 2005, the portion of these revenues used for transit operations and maintenance, and the percentage of total revenues from these funds used for this purpose.

Table 6: City General Fund and Highway Fund Uses for Transit O&M (Millions $)

	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005
General Fund Total Revenue	$552.8	$574.6	$570.3	$622.3	$705.0
Highway Fund Total Revenue	$102.9	$106.9	$108.0	$117.9	$133.3
Total	$625.7	$681.5	$678.3	$740.2	$838.4
General Fund Transit O&M Uses	$37.5	$46.4	$40.6	$40.5	$29.7
Highway Fund Transit O&M Uses	$27.0	$30.4	$36.5	$34.9	$49.4
Total City Revenue to Transit O&M	$64.5	$76.9	$77.1	$75.4	$79.2
Percentage to Transit O&M	9.8%	11.3%	11.4%	10.2%	9.4%

Source: City and County of Honolulu, Department of Budget and Fiscal Services

5.0 POTENTIAL FUNDING SOURCES

This section describes the methods, procedures and assumptions that will be used to assess alternative funding sources available to the City for implementing transit improvements. Current FTA guidelines require that the City examine mechanisms to augment operating revenues and capital funding from non-traditional sources. Alternative financing strategies will examine approaches outlined in the FTA Innovative Financing Initiative and provide an important role in closing the gap between existing funding and potential revenue shortfalls.

Alternative funding techniques will be organized into the following three categories.

- Real Estate-Related Techniques
- Negotiated Capital Investments
- Private-Sector Financing

The financial analysis will evaluate the potential for implementing alternative funding sources for the alternatives. As a first step, potential revenue sources and funding techniques will be described. The types and sources of data required to analyze each technique will be identified. Each potential source will then be evaluated according to its potential revenue "yield," feasibility of implementation, sensitivity to changing local economic conditions, and ease of administration and collection.

5.1 REAL ESTATE-RELATED SOURCES

Real estate-related sources are often relied upon by transit agencies to generate capital funding and operating revenues from the use of real property needed for the construction and operation of transit services. Several typical sources used include the following.

5.1.1 Joint Development and Air Rights Development

These techniques generate revenues from the sale or lease of development rights associated with real property owned or operated by the transit agency. Examples include long-term ground leases of land owned (or to be acquired) by various transit districts in the San Francisco Bay Area (AC Transit, BART, VTA) for privately constructed development, commonly referred to as joint development; the transfer of development rights at station properties to nearby land for private sector development; and the lease of air rights above station property to private developers. Joint development and air rights development have been actively promoted by FTA and are considered to be successful transit-oriented real estate development techniques.[5]

[5] Policy on Transit Joint Development, Federal Transit Administration, published in the Federal Register, March 14, 1997.

In addition, a number of communities around the nation have sought to encourage new, affordable residential development adjacent to or within walking distance of rail stations to encourage transit ridership. This helps meet the need for more affordable housing as well as induce the development of more walkable and transit-convenient communities. An example of this approach is a program adopted in the late 1990s for the San Francisco Bay Area by the Metropolitan Transportation Commission (MTC). The program, known as the “Transportation for Livable Communities” (TLC) initiative, provides funds to local communities for planning and capital improvement projects, such as streetscapes, bike and pedestrian facilities and transit-oriented development. This initiative is funded with flexible federal transportation funds. In 2001, MTC also initiated the “Housing Incentive Program” (HIP), which distributes funds to local jurisdictions as a “reward” for locating new compact housing near transit stations.

5.1.2 Negotiated Capital Investment

Negotiated capital investments are agreements between private developers and public agencies to finance a portion of a transit improvement project in return for benefits from the transit agency. For example, a major employer or land owner may donate land for construction of a station in its vicinity. Other examples include funding for station construction and station enhancements or amenities (e.g., park-and-ride facilities, art work, etc.).

5.1.3 Fees and Assessments

Revenues for operating and capital costs can be generated by levying fees or assessments on existing or new property within a well-defined area that will benefit directly from the proposed transit improvements. Examples include:

- Transit Impact Fees. A one-time fee levied on new development to mitigate the impacts of new development on transit.
- Benefit Assessments. An annual assessment on property owners, based on the benefits they derive due to their proximity to a transit station.
- Tax Increment Financing. This method is used almost exclusively by redevelopment agencies and involves estimating and allocating a portion of increased property tax revenues attributable to finance the transit improvements.

Implementation of these techniques is often limited by political constraints associated with implementing new fees or tax measures. Section 34 of the City’s Code of Ordinances is the enabling legislation for the creation of assessment districts on O‘ahu.

5.1.4 Private-Sector Participation

These techniques cover innovative private-sector initiatives for implementation, operation and maintenance of capital improvements. Such initiatives provide benefits through reducing net public costs by sharing risk and tax benefits with the private sector through the use of off-shore financing techniques, vendor financing, franchise arrangements, and turnkey construction. Benefits from private-sector participation can include reduction in interest rates for debt financing or changes in the payment schedule of assets. Private-sector participation can also reduce or share risks of project completion, construction cost overruns, and operating deficits. However, while private sector participation can potentially lead to important cost savings, their magnitude and timing may be such that their contribution to the financial viability of the project should be considered minor.

- Vendor Financing. This approach permits the transit agency to benefit from lower interest costs and tax benefits available to foreign and domestic private companies.

- Leveraged leases for facilities and equipment.

- Franchise arrangements transfer the risks of completion, capital cost, and operating deficit to the private sector. Relatively few applications of this type of procurement have been pursued in the transportation industry.

- Turnkey Construction. In this approach, the private sector, usually a consortium of firms, bid for the complete engineering, construction, and vehicle procurement of a transit system. As a result, the completion and capital cost risks and transferred to the private sector. This approach is actively being used by the transportation industry, but has been applied with varying degrees of success.

6.0 MAJOR DATA SOURCES

The financial analysis task will focus on identifying and quantifying alternative financing techniques that have been successful in other cities with comparable bus and rail projects. These techniques will be evaluated and applied as appropriate to the corridor alternatives.

In addition, data concerning the local economy will be obtained from local government sources including OMPO and the City's Transportation Services and Planning and Development Departments. Data pertaining to general economic conditions and trends will be augmented by other sources, such as major banks and university research centers, as appropriate and available.

Information concerning local land use patterns and real estate market conditions will be acquired from the City, particularly zoning and general plan and policy documents. Research on market conditions will focus on data provided by local real estate analysts (e.g. Colliers Monroe Friedlander), which provide quarterly reports on current market rents, vacancy rates, market demand, and current and projected absorption rates.

Material concerning development potential will be obtained from review of existing general plan designations and discussions with local real estate brokers. Real property and incremental tax rates will be furnished by the Real Property Assessment Division of the City's Budget and Fiscal Services Department. In the case of tax increment financing, the ability of redevelopment agencies to allocate funding for transit improvements will be examined.

Data obtained for private sector participation techniques will rely on the experience of other transit agencies, such as the City and County of Honolulu. In addition, the ability of the City to implement specific financial mechanisms will be discussed with financial advisors, investment bankers, and City staff.

6.1 USE OF POTENTIAL SOURCES OF REVENUE

The Financial Analysis Results Report will describe the timing and amount of revenues that may be generated from each potential source. Revenues suitable for capital, operating and maintenance costs will be identified. In addition, revenues that may be appropriate for systemwide replacement and rehabilitation costs will be reviewed. The potential loss of funds for major capital costs such as land, civil works and engineering, planning, insurance ("soft costs") will also be examined.

Sources of revenues will be analyzed with particular emphasis on the sensitivity of revenue levels and collection to external factors. For example, real estate techniques generate revenues from long-term lease arrangements, which often have inflation adjustments, and can be collected on a monthly basis. In contrast, fees and assessments are tied to the level of an existing tax base, and generate revenues from annual or periodic assessments.

Alternative funding sources will be applied to each transit improvement alternative within a cash flow context to determine financial viability. Each source will be described in terms of the range or order-of-magnitude of funding that realistically can be accomplished, the timing of revenues or financing, and an evaluation as to the implementability of each source.

This analysis will be summarized in a table matrix format which identifies feasible alternative funding strategies for each transit alternative. The table will include an estimate of the range of revenues that would be generated from each technique and identify the type of revenues (e.g., operating and capital).

7.0 EVALUATION OF PROCESS AND SENSITIVITY TESTING

7.1 ASSESSING FINANCIAL CAPACITY

Financial capacity refers to the ability of the City to fund existing and future operating and capital requirements. This measure compliments the analysis of current financial condition. Combined, financial condition and financial capability complete the assessment of financial capacity, as defined by FTA.

The analysis of financial capacity addresses the underlying economic vitality of the area, ability to leverage federal and state sources of revenue, burden of transit capital investments, and operating performance. Upon completion, the analysis results are documented in the Financial Analysis Results Report.

While most of the measures used to assess financial condition will be applied in the prospective context of financial capacity analysis, our analyses will address the following types of measures:

Ending cash balances: The cash flow analysis will be structured to demonstrate that sufficient working capital is maintained in each year-end cash balance. A typical measure is three months of current or prior year operating expenditures.

Debt coverage ratios: The ratio of dedicated revenues to debt service should be assessed, based on the level of uncertainty in the cost and revenue estimates. Projections made during our analysis will be based on relatively conservative debt coverage ratios (on the order of 1.5 to 2.0). This measure of financial capacity will only be used if debt financing is required to meet capital cash flow needs.

7.2 SENSITIVITY TESTING

The financial capacity analysis that will be conducted will be based on assumptions regarding trends on future revenues and costs. Because many of these costs and revenues are variables that are beyond the exclusive control of the City, there is an inevitable degree of uncertainty about how these variables such as operating costs and receipt of funding will behave in the future.

As a result of this uncertainty, sensitivity testing is performed in order to determine how financial capacity is affected if the forecasts of certain variables prove either too optimistic or pessimistic from the assumptions used in the capacity analysis.

The candidates for potential testing were identified in Section 4.0 of this report. Once this list if finalized, a decision will be made regarding the levels (or ranges) at which each variable will be tested. For example, if GET receipts are the variable selected for sensitivity testing, and the capacity analysis assumed that the receipts would grow at 4 percent per year, alternative growth rates must be selected for sensitivity testing. These alternative rates might be set of 3 percent or at 5 percent to examine the impacts of these potential changes on the City's financial capacity. Once each variable has been selected, the cash flow model will be used to test the impact on either annual cumulative ending cash balances or debt service coverage ratios, depending on the variable being tested.

Sensitivity testing will be augmented by selected risk analysis on certain variables. This risk analysis would involve the assignment of a frequency distribution (or probability) to a specific variable range. Assigning probability to particular events (i.e., the likelihood of sales tax receipts growing at 5 percent as opposed to 4 percent) allows the City to determine the probability, i.e., risk, of a particular event taking place. These various "weighted" events or outcomes are then evaluated to determine the resultant "probable" outcome. The risk analysis may indicate a probable result or outcome significantly different than what the initial capacity analysis demonstrates.

8.0 SUMMARY

The purpose of the Financial Analysis Methodology Report has been to:

1. Describe the process to be followed and the tools to be used for conducting the financial condition and capacity analysis required in an FTA project development process;
2. Identify existing and potential revenue sources and uses to be evaluated during the financial analysis; and
3. Describe the evaluation process and the purpose of sensitivity testing.

The successful completion of the financial analysis tasks will require close cooperation among a number of organizations, including the City, OMPO, and the FTA, and private sector groups within the corridor. The analysis will also depend on the integration of capital and operating costs and other information to be developed by the consultant team as part of the AA and DEIS.